REFERENCE 13

EBASCO

IEPA-93-32

April 7, 1993

Mr. Steven L. Gobelman, P.E.
Remediation Engineering Sub-Unit
Remedial Project Management Section
Bureau of Land
2200 Churchill Road
Springfield, Illinois 62794-9276

Subject: Professional Service agreement No. BIE 9023
Sandoval Zinc - LPC #1210500002
Draft Feasibility Study Report

Dear Steve:

Please find enclosed for your review a copy of the Draft Feasibility Study Report for the Sandoval Zinc Site located in Sandoval, Illinois. The Executive Summary will be completed once approval of the report contents has been finalized. If you have any questions concerning the report please do not hesitate to call me.

Sincerely,

EBASCO Environmental

James Brinkman
Senior Engineer

RECEIVED
APR - 8 1993
IEPA/DLPC

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1.0 INTRODUCTION

The Illinois Environmental Protection Agency (IEPA) contracted with Ebasco Services Incorporated (EBASCO) to perform a Feasibility Study on the Sandoval Zinc Site located in Sandoval, Illinois, under the terms of State Multi-Site Professional Services Agreement Contract No. BIE-9023. The defined scope of work for this project included the following seven tasks:

Task 1 - Information Review
Task 2 - Information Summary
Task 3 - Data Needs and Assessment
Task 4 - Strategy Meeting
Task 5 - Feasibility Study
Task 6 - Topographic Map of Site
Task 7 - Project Task Control

After completing Task 4, EBASCO determined that there was insufficient information available to complete the feasibility study ("Information Summary and Data Assessment" Report; April 14, 1989) and recommended a supplemental field investigation. A Work Plan and Field Sampling Plan (dated June, 1989) were subsequently prepared for the supplemental field investigation.

This document is the feasibility study report based on all previously collected data and documents as well as the supplemental field investigation conducted by EBASCO. Sections 1 through 5 include a description of the investigation objectives, site background information, the study area, its physical characteristics (geology and hydrogeology), the nature and extent of impacted media, and conclusions drawn from the field investigation. These first five sections of the report cover the basic elements of a Remedial Investigation (RI) report. Sections 6 through 8 identify Applicable or Relevant and Appropriate Requirements (ARARs), screen relevant remedial technologies, develop appropriate remedial alternatives and compare the remedial alternatives. These last three sections of the report cover the basic elements of a Feasibility Study (FS). Section 9 lists the references used in preparing this report.

1.1 <u>Field Investigation Objectives</u>

The primary goals of the supplemental field investigation conducted by EBASCO in May and June, 1990, with a second phase sampling effort in April 1991, were as follows:

- o Develop specific information about the nature, extent, and level of contamination at the Sandoval Zinc site.
- o Determine the physical and chemical background characteristics of the soil and the chemical background characteristics of the groundwater.
- o Define the nature and extent of impacted soils, surface water, sediment, groundwater on-site.
- o Evaluate potential off-site contaminant pathways in soil, surface water, and groundwater that may affect public health and the environment.
- o Identify and evaluate potential alternatives for remediation.

1.2 Site Background

The Sandoval Zinc site (IEPA Site Inventory Number 1210500002) is an abandoned zinc smelter facility located southeast of the town of Sandoval in Marion County, Illinois (Figure 1-1). The site covers approximately 12 acres and is relatively flat, owing to the large quantity of artificial fill (metal-rich cinders from the smelting process) that was used to level the site's natural topography.

1.2.1 Site Description

The Sandoval Zinc site is comprised of two large abandoned buildings, an abandoned railroad tank car (also referred to as the above ground storage tank), old furnace building ruins, a "farm pond" to the east, and a marshy area to the west (Figure 1-2). The site is covered with grey cinder fill and little vegetation grows on the fill material. Surface water runs off into drainage ditches located east and west of the on-site buildings. Fill material also appears to be carried by surface water runoff past the property line and is accumulating in the field immediately south of the fence line. Since the site slopes several feet down towards the "farm pond", it likely also receives surface water runoff from the site.

1.2.2 Site History

The Sandoval Zinc smelter facility began operating as a primary zinc smelter some time between 1885 and 1890. Approximately twenty-five years later, in 1915, the operations were converted to secondary zinc smelting and the facility continued to operate in this manner until the facility was closed in the 1980s. On June 27, 1972, the plant was almost entirely destroyed by fire. The buildings were rebuilt and the plant continued to operate until 1985. On December 19, 1986, the Sandoval Zinc Company was officially dissolved and the owners declared bankruptcy.

For the first 85 years of operation, the principal waste emissions from the plant were metal-laden cinders and windblown ash. Large quantities of the cinders from the smelting process were used in constructing and surfacing secondary roads in the plant area and as fill material on the plant property. As a result, a layer of metal-rich cinders, ranging from 1 to 10 feet in thickness, now covers approximately 12 acres of the plant site.

The windblown ash from the smelter stack settled on the plant site and the surrounding farmland. Assuming the plant was fairly typical of secondary zinc smelters using retort processing, these air emissions were probably rich in heavy metals and ranged from 50 to 100 tons per year from the retort alone. Additional wind-borne emissions could have been generated from plant waste-handling procedures such as open storage of cinders and ash, and bulk storage of products (principally zinc oxide) in bins within plant buildings.

In compliance with air pollution control regulations, a scrubber was installed on the plant stack in 1970. Wastewater from the scrubber was dewatered in a seepage pit constructed on-site. This pit held the sludge from the process until it was removed for zinc reclamation. Another pit was used for the disposal of baghouse dust and floor sweepings. Based on the information available the exact locations of the pits are currently not known.

1.2.3 Previous Investigations

The Illinois State Water Survey (ISWS) and the Illinois State Geological Survey (ISGS) carried out geologic and groundwater studies at the site from 1975 to 1982. The final study report, entitled Retention of Zinc, Cadmium, Copper, and Lead by Geologic Materials[1], was published in 1982. Forty-nine monitoring wells were installed on-site at thirty-six different locations during the study and provided the primary source of information for the site. The study described the geologic materials underlying the site as follows:

Peoria Loess
Roxana Silt
Berry Clay (Glasford Formation)
Hagarstown Member (Glasford Formation)
Glasford Till
Lierle Clay (Banner Formation)
Banner Till
Bond Formation Shale

During the study, soil samples were collected from a variety of locations across the site and from control borings located approximately three miles south-southwest of the site. The samples were analyzed for cadmium, copper, lead, and zinc. Background concentrations for the four heavy metals tested were 20 to 50 mg/kg for zinc, 0.04 to 1.5 mg/kg for cadmium, 10 to 30 mg/kg for copper, and 10 to 40 mg/kg for lead. Based on these background samples, there appeared to be no significant naturally occurring chemical variation with depth or between geologic unit boundaries. However, some zinc levels in isolated Pleistocene soils were higher than the established background levels.

According to the ISWS/ISGS report, the zinc processing waste covering the site varies widely in metals content but is generally rich in zinc, lead, copper, and aluminum. Cadmium was also detected in the soil samples collected. One sample of waste material at the site was 76 times the EP Toxicity Standard for lead. This large volume of material represents both a potential environmental hazard as well as a source of reclaimed metals. Typical weight percentages of the metals are 23% zinc, 3.8% aluminum, 2.5% lead, and 0.5% copper. These heavy metals have penetrated site overburden to depths of up to 28 feet.

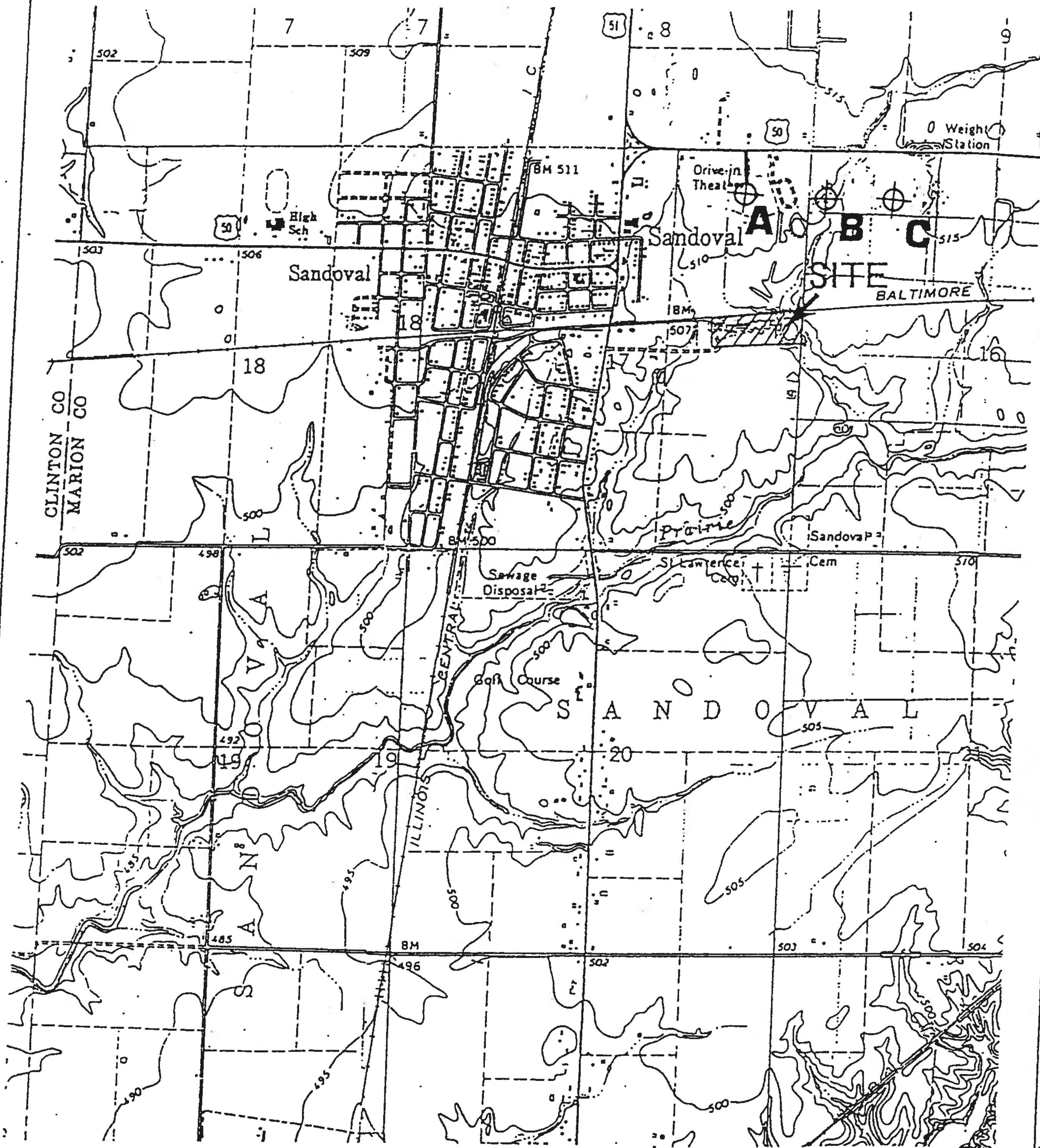
Piezometric surfacewater maps constructed by the ISWS/ISGS suggest that the underlying till has an extremely low hydraulic conductivity. The Peoria Loess, Roxana Silt, and Berry Clay appear to allow the slow percolation and infiltration of contaminants downward; however, till units below the Sangamon Soil of the Berry Clay appear to be acting as an aquiclude to the further downward migration of contaminants.

Laboratory analysis of groundwater samples from the monitoring wells sampled in 1975 and 1976 indicated that zinc contaminants had migrated from the wastes, through the soils, and into the groundwater of the Hagarstown Unit. Groundwater maps with contoured zinc concentrations were constructed for the ISWS/ISGS report and are presented in Figure 1-3. The maps show the extent of zinc impacted groundwater in August 1975 and September 1976 and indicate that the zinc plume is migrating from the source areas.

During 1986 and 1987, several sampling activities were conducted by IEPA and the Bureau of Mines at the Sandoval Zinc site. Soil, sediment, surface water, and groundwater samples were collected and analyzed for organic and inorganic parameters. The results of these sampling efforts are summarized in Tables 1-1 through 1-10. In March 1987, water and sediment samples were collected from the drainage ditches at the eastern and western edges of the site. Zinc and cadmium concentrations in the surface water samples exceeded the ambient surface water quality limits set forth in Section 304.124 of Subtitle C, IEPA's Water Pollution Regulations[2]. These limits are 1.0 mg/l and 0.15 mg/l for zinc and cadmium, respectively. High levels of these two heavy metals as well as other metals were detected in sediment samples collected downstream of the site. Zinc and cadmium concentrations averaged greater than 17,000 mg/kg and 14 mg/kg, respectively in downstream sediments samples. The impacted waters and sediments in the drainage ditches could potentially reach Prairie Creek, approximately one-half mile from the site. However, the extent of migration of the waters and sediments is not fully known since sampling is relatively recent, and noncomprehensive in scope.

The ISWS/ISGS study identified that the primary mechanisms retaining the metals in the soils at the site were cation exchange and the precipitation of insoluble metal compounds due to changes in soil pH. Elevated levels of calcium and magnesium in groundwater samples during the IEPA studies of 1986 and 1987 suggested that cation exchange is continuing.

EBASCO performed a preliminary site visit on March 9, 1989. The purpose of the visit was to gather information necessary for preparing a Work Plan. During this visit, EBASCO made a preliminary assessments of sampling sites by matrix and location, determined the appropriate levels of personal protective equipment required, identified existing monitoring well locations and made an overall assessment of site conditions. On site and adjacent areas were visually inspected for contamination, including signs of surface water contamination, vegetation stress, physical hazards, and other environmental hazards. A complete description of the site visit and a photo log documenting those areas exhibiting signs of contamination are given in the Information Summary and Data Assessment Report[3].



Residential Well Location
Inorganic Concentrations in ug/l
SCALE 1:24000

1000 0 1000

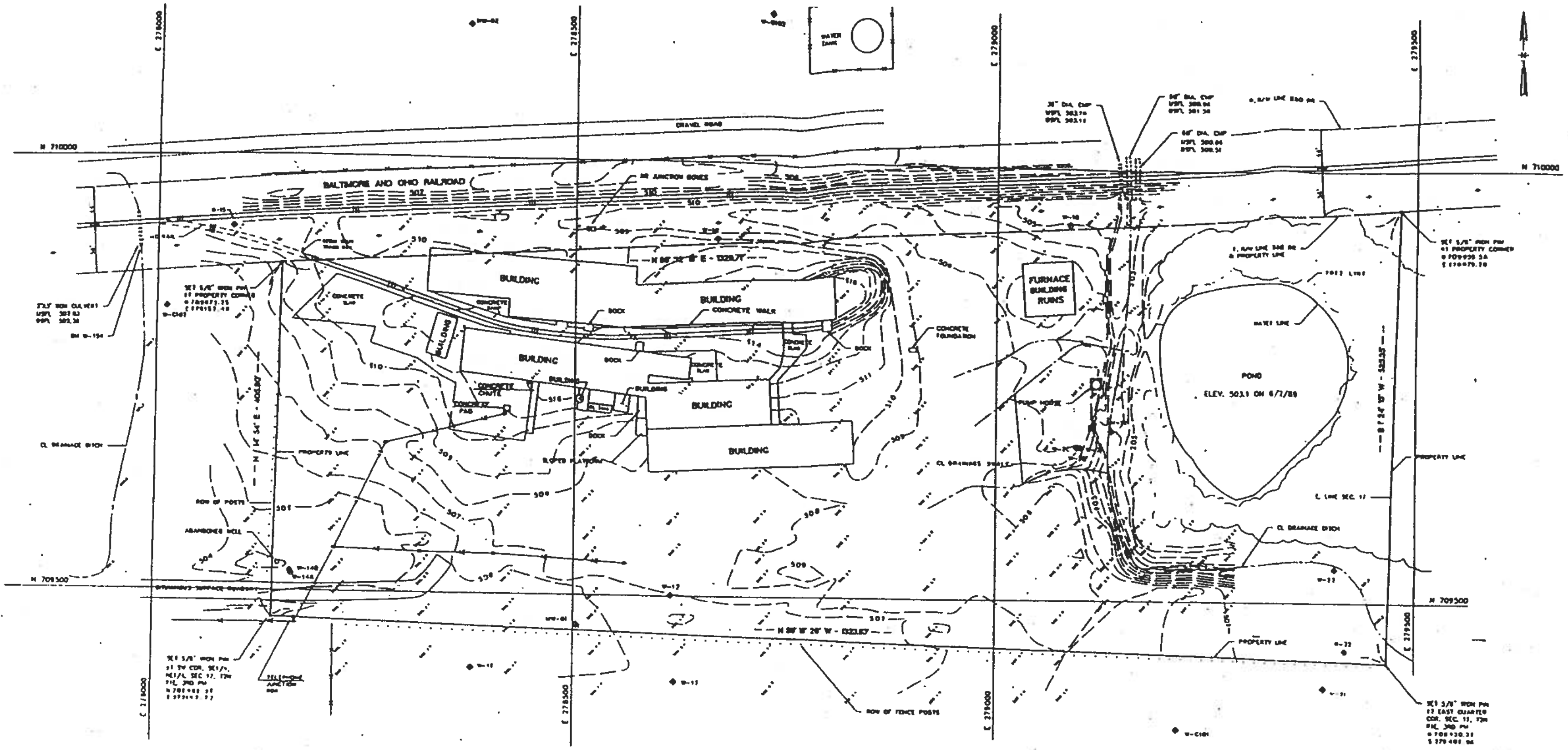
CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL

N

Illinois Environmental Protection Agency

Sandoval Zinc Site

Figure 1-1
Residential Well and Site Location Map



MONITOR WELL DATA

WELL NO.	N. COORD.	E. COORD	TOP CASE. ELEV.	GROUND ELEV.
W-2A	709676.56	279099.70	508.36	507.7
W-2B	709676.67	279097.85	508.31	507.9
W-2C	709676.86	279095.30	508.33	508.1
W-4A	709179.81	278160.72	509.91	507.5
W-4B	709179.12	278156.39	508.45	507.3
W-9A	710201.35	279002.22	508.55	505.0
W-9B	710200.47	279005.20	506.20	504.9
W-10	709838.31	279085.79	507.12	504.9
W-13	709500.76	278615.70	509.38	507.5
W-14A	709518.79	278108.72	507.63	504.9
W-14B	709522.45	278165.90	507.85	504.9
W-16	709414.28	278378.10	506.99	508.3
W-17	709401.20	278618.65	509.38	506.2
W-18	709912.21	278686.41	511.01	510.1
W-27	709443.88	279418.84	505.16	503.8
W-73	709538.76	279403.38	504.07	502.7
W-37	709894.82	279132.78	504.81	504.7
W-5A	709154.39	278621.10	510.38	507.7
W-5B	709154.27	278619.70	508.72	507.6
W-C101	709352.38	279214.82	512.47	509.5
W-C102	710170.86	278778.10	509.23	508.3
W-C103	709824.98	278011.90	506.15	505.5
MW-01	709463.57	278608.07	508.12	505.1
MW-02	710161.22	279273.21	508.20	507.0

LEGEND

- POWER POLE
- COMMUNICATION POLE
- TELEPHONE JUNCTION BOX
- ELECTRIC LINE
- RAILROAD
- FENCE LINE
- MONITOR WELL

CONTOUR INTERVAL = 1'

LOCATION MAP

LEGAL DESCRIPTION

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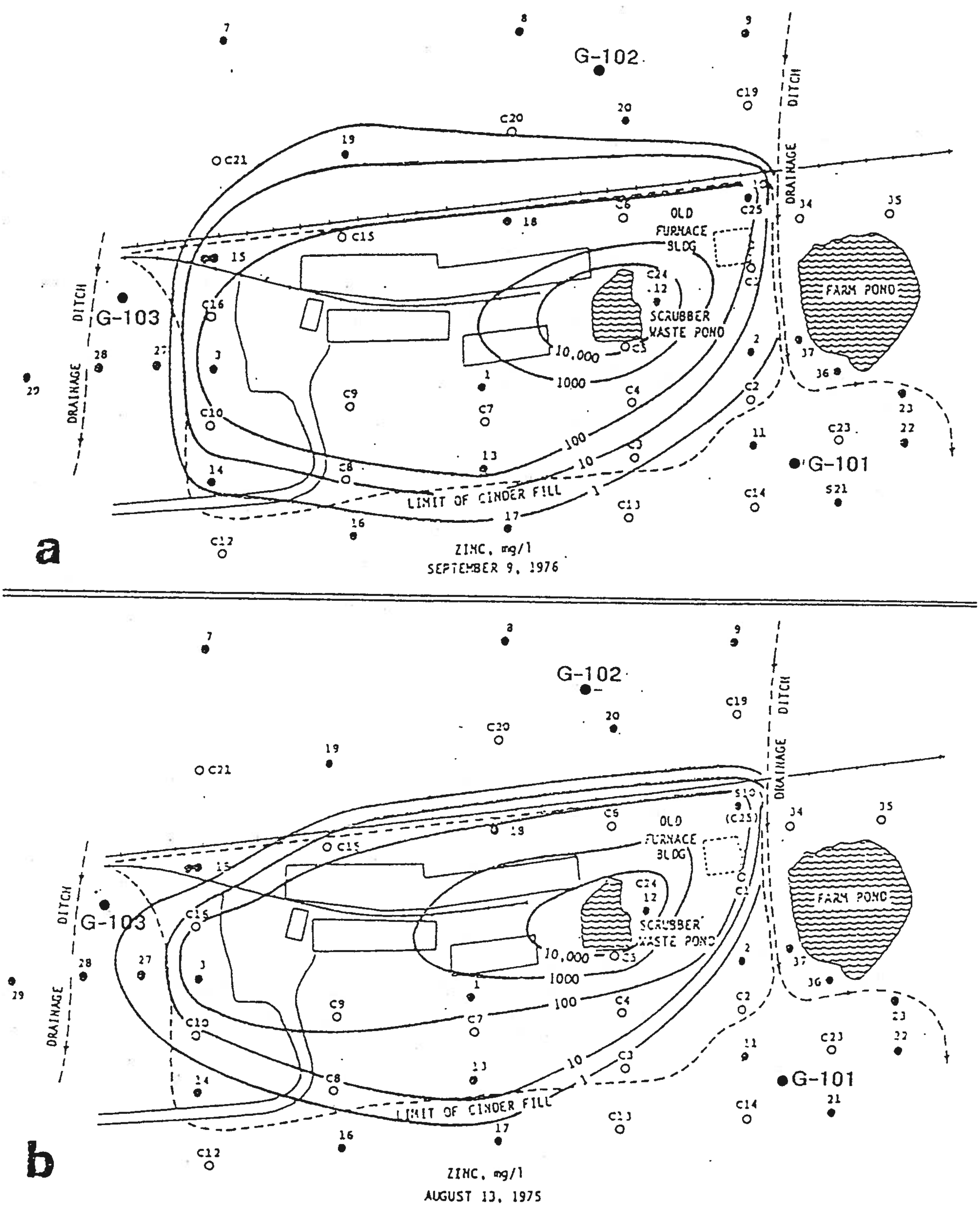
Sandoval Zinc Site

Figure 1-2

Study Area Map

EBASCO SERVICES INCORPORATED



Scale (feet)

0 100 200 300

o Core Hole

● Monitoring Well

N

Illinois Environmental Protection Agency

Sandoval Zinc Site

Figure 1-3

Zinc Plume With IEPA Monitoring Wells Superimposed

EBASCO SERVICES INCORPORATED

Table 1-1
Summary of Analytical Results From
Previous IEPA Study - Soil (ug/g)
Sandoval Zinc
Sandoval, Illinois

PARAMETER	X101	X102	X103	X201	X202	X203	X204	X205
Antimony	14	14	30	140	28	41	14	32
Arsenic	7	13	10	4	17	26	11	11
Beryllium	1	1	1	1	3	1	1	1
Cadmium	27.2	26.6	14.2	35.1	21.9	19.6	60.9	110
Chromium	39.1	18.1	23.5	1,360	9.8	9.2	22.9	22.2
Copper	1,240	418	880	34,200	320	1,780	1,560	2,810
Lead	7,560	1,590	5,650	25,800	40,000	10,000	69,600	22,400
Mercury	0.36	0.04	9.43	0.11	0.28	0.25	4.55	5.79
Nickel	570	14.4	230	12,100	52	220	610	800
Selenium	6	6	2	20	12	4	6	6
Silver	3.1	0.8	2.5	5.1	5.2	4.4	1.9	3.2
Titanium	3	3	2	2	6	2	3	3
Zinc	71,100	8,360	56,700	16%	40.3%	26,400	32.8%	19.5%

Note: Samples collected by IEPA on July 25, 1986.

Table 1-2
Summary of Analytical Results Collected By IEPA -
Surface Water Samples (mg/l)
Sandoval Zinc
Sandoval, Illinois

PARAMETER	S101	S102	S103	S104	S105	S0106
Aluminium	0.33	0.51	0.54	0.84	1.9	2.2
Antimony	0.006	0.004	0.003	BDL[1]	0.003	BDL
Arsenic	BDL	BDL	BDL	BDL	0.022	BDL
Cadmium	0.510	0.465	0.59	0.021	0.59	0.13
Chromium	0.018	0.018	0.018	0.022	0.022	0.022
Copper	0.041	0.038	0.027	0.01	0.034	0.01
Iron	0.75	0.83	0.59	1.2	1.4	1.8
Lead	0.076	0.052	0.048	0.014	0.034	0.006
Mercury	BDL	BDL	BDL	BDL	BDL	0.0002
Nickel	0.15	0.11	0.09	BDL	0.07	BDL
Silver	0.008	0.007	0.01	0.007	0.01	0.008
Zinc	52	46	20	0.65	23	0.12

1 - Below Detection Limit (BDL)

Note: Samples collected by Dennis Newman on March 30, 1987.

Table 1-3
Summary of Analytical Results Collected By IEPA - Sediment Samples (mg/kg)
Sandoval Zinc
Sandoval, Illinois

PARAMETER	X101	X102	X103	X104	X105	X106	X110
Aluminium	4,733	8,732	7,712	5,029	5,476	7,020	2,344
Antimony	1.6	0.26	BDL[1]	0.5	0.27	0.28	16
Arsenic	26	24	18	15	BDL	12	12
Cadmium	24	13	19	7.4	1.5	2.2	46
Chromium	34	41	22	25	11	18	20
Copper	1,065	960	252	688	38	71	1,250
Iron	20,710	17,990	7,854	8,621	5,476	9,200	5,370
Lead	710	1,660	15	1,026	189	140	1,760
Mercury	2.5	0.43	0.08	0.18	0.05	0.04	2.7
Nickel	716	515	117	287	5.4	28	114
Silver	2.2	2.5	1.4	1.6	1.0	1.1	8.0
Zinc	15,310	24,230	4,863	13,700	507	1,158	62,400

1 - Below Detection Limit (BDL)

Note: Samples collected by Dennis Newman on March 30, 1987.

Table 1-4
Summary of Analytical Results Collected By IEPA - Additional Soil Samples
Sandoval Zinc
Sandoval, Illinois

PARAMETER	SAMPLE X101		SAMPLE X102		SAMPLE X103	
	Total (mg/kg)	E.P. Toxicity (mg/l)	Total (mg/kg)	E.P. Toxicity (mg/l)	Total (mg/kg)	E.P. Toxicity (mg/l)
Aluminium	6,030	0.64	5,860	1.03	1,930	0.68
Antimony	BDL[1]	BDL	BDL	BDL	69.8	BDL
Arsenic	28.1	BDL	38.5	BDL	25.2	BDL
Cadmium	23.3	0.5	60.3	1.0	7.6	0.1
Chromium	16.6	BDL	32.2	BDL	8.79	BDL
Copper	1,850	3.0	2,710	9.0	956	2.0
Iron	12,900	0.99	14,600	BDL	5,280	BDL
Lead	29,200	381	10,600	14.2	38,900	106
Mercury	8.8	BDL	1.3	BDL	1.2	BDL
Nickel	547	3.0	281	1.0	114	0.6
Silver	3.82	BDL	7.92	BDL	4.36	BDL
Zinc	226,000	2,400	281,000	1,800	493,000	2,200

1 - Below Detection Limit (BDL)

Note: Soil samples collected on April 9, 1987.

Table 1-5
Summary of E.P. Toxicity Results (mg/l) Collected By IEPA
Sandoval Zinc
Sandoval, Illinois

PARAMETER	X101	X201	X301
Aluminium	BDL[1]	BDL	BDL
Antimony	BDL	BDL	BDL
Arsenic	BDL	BDL	BDL
Cadmium	0.007	0.011	0.02
Chromium	0.01	0.02	0.01
Copper	BDL	BDL	BDL
Iron	1.1	0.13	0.1
Lead	0.009	0.018	BDL
Mercury	BDL	BDL	BDL
Nickel	BDL	BDL	BDL
Silver	BDL	BDL	BDL
Zinc	0.23	0.005	0.097

1 - Below Detection Limit (BDL)

Note: Samples collected by Kevin Rodgers on April 27, 1987.

Table 1-6
Summary of Analytical Results Collected By Bureau of Mines
Sandoval Zinc
Sandoval, Illinois

Analyte	Concentration (Weight Percent)
Aluminum	14.9%
Carbon	9.0
Iron	2.8
Lead	2.5
Silicon	14.9
Zinc	23.0

Note: Sample was a composite soil sample collected by R.L. Johnson on February 20, 1987.

Table 1-7
Summary of Organic Analytical Results
Collected by Environdyne - Groundwater (ug/l)
Sandoval Zinc
Sandoval, Illinois

PARAMETER	G101	G102	G103
Diethylphthalate	2	7	-
Di-N-Butylphthalate	2	2	2
Hexanedioic Acid, Dioctylester	62	98	-
Carbon Disulfide	-	2	-
Benzene	-	3	1
Di-N-Octylphthalate	-	3	-
2 (3H) Furanone, Dihydro	-	9	-
Hexanoic Acid, 6-Amino	-	12	-
Unknown	-	4	-
Unknown	-	-	10
Unknown	-	-	7
Unknown	-	-	44

Note: Groundwater samples collected May 14, 1987

Source: Environdyne PA/SI

Table 1-8
Summary of Inorganic Analytical Results
Collected by Environdyne - Groundwater (ug/l)
Sandoval Zinc
Sandoval, Illinois

PARAMETER	G101	G102	G103
Aluminium	BDL[1]	BDL	82
Antimony	BDL	BDL	BDL
Arsenic	BDL	BDL	BDL
Cadmium	BDL	BDL	BDL
Chromium	BDL	BDL	BDL
Copper	BDL	BDL	BDL
Iron	140	BDL	61
Lead	2	BDL	BDL
Mercury	BDL	BDL	BDL
Nickel	BDL	BDL	BDL
Silver	BDL	BDL	BDL
Zinc	36	24	110
Sulfate	276,000	89,600	273,300
Sulfide	BDL	BDL	1,600

1 - Below Detection Limit (BDL)

Note: Groundwater samples collected May 14, 1987

Source: Environdyne PA/SI

Table 1-9
Summary of Organic Analytical Results
Collected by Environdyne - Soil (ug/kg)
Sandoval Zinc
Sandoval, Illinois

PARAMETER	S101	S102	S201	S202
Acetone	63	160	76	
2-Butanone	-	21	7	
2 (3H) - Furanone, Dihydro	-	1,856	1,608	1,831
Toluene	-	15	-	-
Chloroform	-	-	-	6
Naphthalene	-	-	-	190
Dibenzofuran	-	-	-	190
Phenanthrene	-	-	-	1,00
Anthracene	-	-	-	220
Fluroanthene	-	-	-	1,100
Pyrene	-	-	-	1,400
2-Methylnaphthalene	-	-	-	900
Benzo (a) Anthracene	-	-	-	570
Chrysene	-	-	-	1,300
Benzo (b) Fluoranthene	-	-	-	710
Unknown Organics[1]	-	40,000	45,000	24,000

Note: Samples collected May 14, 1987

Source: Environdyne PA/SI

Table 1-10
Summary of Inorganic Analytical Results
Collected by Environdyne - Soil (ug/kg)
Sandoval Zinc
Sandoval, Illinois

PARAMETER	S101	S102	S201	S202
Aluminum	10,500,000	15,300,000	15,200,000	10,300,000
Antimony	43,600	BDL	BDL	BDL
Arsenic	27,500	14,300	5,670	4,900
Cadmium	49,000	44,600	23,200	11,200
Chromium	18,600	14,400	16,600	41,400
Copper	446,000	129,000	67,200	1,370,000
Iron	32,100,000	15,300,000	18,500,000	41,600,000
Lead	1,226,000	272,000	139,000	4,662,000
Mercury	BDL	BDL	BDL	670
Nickel	199,000	40,000	20,600	334,000
Silver	BDL	BDL	BDL	1,500
Zinc	10,300,000	6,030,000	3,770,000	44,700,000
Cyanide	350	BDL	BDL	BDL
Sulfate	?	2,600	?	110,200
Sulfide	BDL	7,600	34,200	BDL

Note: Samples collected May 14, 1987

Source: Environdyne PA/SI

2.0 STUDY AREA INVESTIGATION

This section presents the scope of the supplemental field investigations and describes how each component of the investigation was conducted.

2.1 Scope of Supplemental Field Investigation

The supplemental field investigation effort at the Sandoval Zinc site focused on collecting the data needed to sufficiently characterize the site in order to evaluate and select remedial actions that would adequately protect human health and the environment. Prior to beginning the field activities, a Work Plan, including a site-specific Field Sampling Plan (FSP), and a Health and Safety Plan (HASP), were developed. A detailed Quality Assurance Project Plan (QAPP) was not developed because all analytical work was performed by an IEPA approved laboratory (ARDL Laboratories) participating in the Contract Laboratory Program (CLP). Additional documents related to the supplemental field investigation and the surveying subcontract were also prepared. The work plan explains the purpose for each component of the investigation including number of samples, locations and analytes.

The EBASCO field activities at the Sandoval Zinc site were conducted from May to June 1990. The investigation included air monitoring, surface soil and sediment sampling, borehole drilling and monitoring well installation, permeability testing at selected monitoring wells, residential well and groundwater sampling, surface water sampling, sampling of waste product and ash from the interiors of the buildings, and sampling the contents of the abandoned above ground storage tank.

2.2 Topographic Survey

A site survey encompassing approximately twelve acres was conducted in June 1989. The final survey map produced includes the natural features and permanent structures located on-site. Also included on the map are ground surface elevations, property boundaries, the locations of the wells and cores of the ISWS/ISGS investigation (where possible), and the location and extent of the "farm pond". The surveying activities were performed by Hanson Engineers, Incorporated, of Springfield, Illinois. Coordinates on-site were established from the Illinois State Plane Coordinate System, East Zone. Four points were set on or near the site as baseline points, two located on the B&O railroad tracks at the northern boundary of the site, and the remaining two points on-site. Elevations were established from a benchmark at the northwest corner of the site and are based on the National Geodetic Vertical Datum (NGVD) of 1929. Supplemental elevations were established as reference points on the Sandoval Water Tank to the north of the site, the four control points, and the tops of monitoring well protective casings, where useable.

Hanson Engineers submitted a report entitled Final Report of Survey Activities, Sandoval Zinc Site, Sandoval, Illinois[4] to EBASCO in July 1989. A copy of the final topographic survey map is provided in Appendix A.

2.3 Aboveground Tank Investigation

The tank investigation was conducted to identify the contents of the abandoned railroad tank car. The tank car is located on the railroad spur at the south side of the westernmost building on-site (Figure 2-1). One composite sample and a duplicate sample were collected from the tank using the sampling procedures outlined in the FSP. EBASCO personnel performed the sampling using Level C protective equipment.

The tank contents were visually inspected for stratification prior to sampling. Clear tubing was lowered into the tank as far as possible and withdrawn. The liquid in the clear tubing was determined to be oil, and was not stratified. The depth of the oil in the tank was approximately three feet eleven inches. The samples collected were analyzed for the volatile organic compounds benzene, toluene, ethyl benzene, and total xylenes (BTEX), the Target Analyte List (TAL) inorganics, pesticides and PCBs, and for heating value.

During the winter of 1991, a valve in the tank piping failed and released all of the residual liquid in the tank. As a result the IEPA conducted an emergency response action and removed approximately 500 cubic yards of petroleum impacted soil. The soil is presently stored inside one of the buildings on-site and the tank is now empty.

2.4 Waste Product/Ash Investigation

The waste product/ash investigation was designed to characterize the ash and waste product that is located in the buildings on-site. Some of the material was in labelled bags (zinc oxide, rock salt), but the majority of the waste product and ash in the buildings had been left in uncovered piles or was scattered across the floors. Composite samples were taken where distinct piles of waste product existed, otherwise samples were collected from scrapings off the floor.

Six samples and one duplicate sample of the waste product and ash were collected from various locations inside the buildings (Figure 2-2). WPA01S and the duplicate WPA01D were collected from an unlabelled bag containing waste product. WPA02S was a composite sample from eight discrete locations within a pile of waste product. Waste product from three sides of an abandoned blower inside the building formed the composite sample WPA03S, and WPA04S was collected from a patch of discolored soil in the doorway to the oil tank. Sample WPA05S was a composite sample collected from various locations around the structures in the center of the building. The final composite sample of waste product/ash (WPA06S) was collected from a location near the door to the building. All samples were analyzed for full TAL inorganics and EP Toxicity.

2.5 Surface Soil and Sediment Investigation

The soil investigation was designed to establish the extent of shallow (less than 1 foot) surface contamination at the Sandoval Zinc site. Surface soil samples were collected from the locations shown in Figure 2-3 and were analyzed for full TAL inorganics. Selected samples were also analyzed for pesticides/PCBs. All surface soil and sediment samples were collected using a garden trowel and were typically collected from the top six inches of the surface soils.

Twenty-three surface soil samples and three duplicate samples were collected to give the most coverage to the surface soil characterization. Some of the samples were taken off-site, from the northern side of the railroad tracks, and outside the southwestern site boundary, and the remaining samples were collected from locations at random across the site and adjacent to the site buildings.

Four sediment samples and one duplicate sample were collected from the perimeter of the farm pond to characterize the surface sediments in this area. SS01S was collected in the drainage ditch at the eastern portion of the site that drains into the farm pond (Figure 2-3). SS02S was a composite sediment sample collected from the western half of the farm pond, and SS03S was a composite sample from four locations on the eastern part of the pond. The last sediment sample, SS04S, was collected from the floodplain area southeast of the farm pond. All sediment samples were analyzed for TAL inorganics and pesticides/ PCBs.

2.6 Surface Water Investigation

The surface water investigation was conducted to characterize the waters of the "farm pond" and in the drainage ditch on the eastern side of the site. The four surface water samples and a duplicate sample were collected from the locations shown in Figure 2-4. Samples were transferred directly to the sample bottles and then labelled for the appropriate analyses.

Surface water sample SW01S and the duplicate SW01D were collected from the water in the eastern drainage ditch. Surface water sample SW02S was collected from the western half of the farm pond, and SW03S from the eastern half of the pond. Sample SW04S was collected from standing water in a depression east of the farm pond. The samples were all analyzed for full TAL inorganics and the volatile organic compounds benzene, toluene, ethyl benzene, and xylene (BTEX).

2.7 Groundwater Investigation

The groundwater investigation was designed to determine the nature and extent of impacted on-site shallow groundwater and possible off-site impacted groundwater. The groundwater investigation consisted of installing two new monitoring wells, locating and assessing the conditions of existing monitoring wells, field permeability testing on selected monitoring wells, and groundwater sampling of five on-site wells and one off-site residential well.

Previous investigations at the Sandoval Zinc site had included the installation of numerous monitoring wells. The Illinois State Water Survey (ISWS) and the Illinois State Geological Survey (ISGS) installed 49 monitoring wells at 36 locations during their study; the Illinois EPA installed three monitoring wells (G101, G102, G103) at the site in 1987. EBASCO performed a site visit in June 1989 and attempted to determine the locations and conditions of these existing monitoring wells. Of the 49 wells installed for the ISWS/ISGS study, only 21 were located. Of these 21, only 13 were usable, and only for obtaining water level measurements. The three monitoring wells installed by IEPA were in good condition and were usable for water level measurements, groundwater sampling, and permeability testing.

The two shallow monitoring wells (MW01 and MW02) were installed during EBASCO's field activities of May and June, 1990. The locations of the two new monitoring wells and the three IEPA monitoring wells are shown in Figure 2-5. The newly installed monitoring wells were completed to depths of approximately 20 feet below ground surface, at the bottom of the Hagarstown aquifer unit. The three IEPA wells were all completed at a depth of approximately 17 feet below ground surface. Information on these five monitoring wells, including installation dates, total depths, screened intervals, and completion zones is given in Table 2-1.

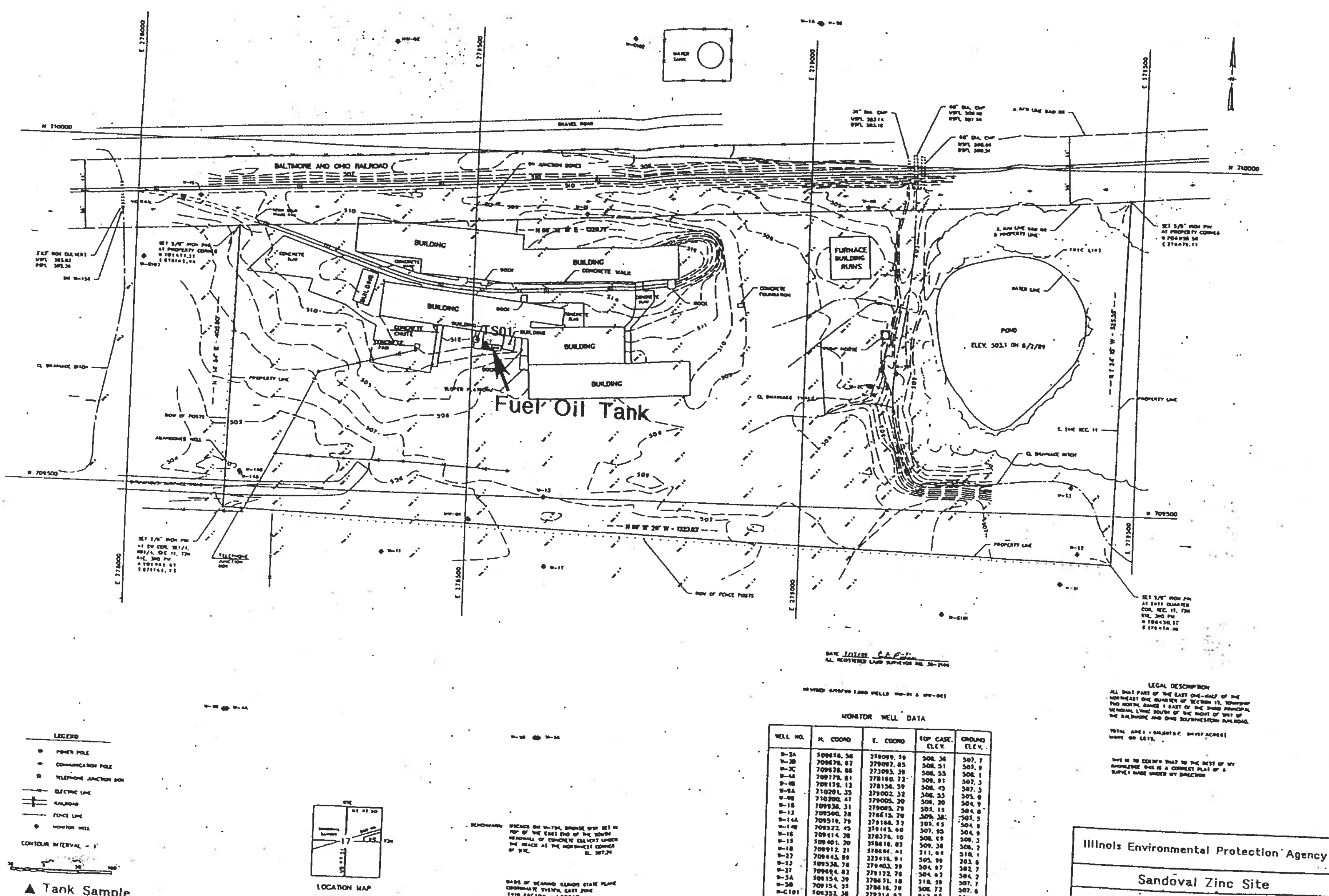
The two monitoring wells were installed using 3 and 3/4-inch inside diameter (I.D.) hollow stem augers with 3-inch I.D. continuous split-spoon samplers. The wells were constructed with 2-inch I.D. stainless steel well casings and risers. The 5-foot long stainless steel well screens had slot sizes of 0.010 inches. A minimum of one foot of sand was put in each borehole before the well casing and screen were lowered down. The sand pack extended approximately two feet above the top of the screen, and a two-foot seal of 1/2-inch diameter bentonite pellets was installed above the sand pack. Cement-bentonite grout was then added to the surface, and the protective casing installed. Figure 2-6 presents a typical monitoring well construction diagram.

The monitoring wells were developed by bailing after a 24 hour stabilization period. Development continued until the parameters (temperature, pH, and conductivity) had stabilized and/or a sufficient well volume was purged so that the water was clear. The water purged from the wells was routed to the nearest surface drainage ditch for disposal.

Slug tests consisting of falling and rising heads were conducted on the IEPA monitoring wells (G101, G102, and G103) in May 1990 and on the two newly installed monitoring wells in June 1990. The slug tests were performed by first measuring the static water level with an electronic tape. Then a 4-foot long, 1 and 1/4-inch outside diameter (O.D.) stainless steel slug was instantaneously lowered into the water until it was fully submerged. The water level drop was measured at timed intervals and recorded using a pressure transducer and data logger. The test continued until the water level in the well stabilized. The rising head test immediately followed, when the slug was removed from the well, and the water level rise was recorded. The data from all the slug tests are provided in Appendix B.

Groundwater samples were collected from the IEPA monitoring wells in May 1990 and from the two new monitoring wells (MW01 and MW02) in June 1990. Sampling at the new monitoring wells was done two weeks after well development was complete. Before the samples were collected, the depth of the water in each well was measured. The depth of the bottom of the well was noted, and the volume of standing water in the well calculated. Three well volumes of water were removed using a stainless steel bailer. The pH, conductivity, and temperature of the groundwater were recorded prior to sampling. The groundwater samples were collected using a stainless steel bailer and poured directly into the appropriate containers. Samples were then sent to the IEPA contract laboratory for full TAL inorganics, pesticides/PCBs, and BTEX volatile organics analyses.

In the approved Work Plan, groundwater sampling was proposed for two of the residential wells located within a one mile radius of the site. During the field investigation of June 1990 only one residential well was located and sampled (Figure 1-1). The groundwater sample and duplicate were analyzed for full TAL inorganics.



MONITOR WELL DATA

WELL NO.	N. COORD	E. COORD	TOP CASE. ELEV.	GROUND ELEV.
W-2A	709658.58	279099.59	508.36	507.7
W-2B	709679.62	279092.85	508.51	505.9
W-2C	709628.88	279095.39	508.55	506.1
W-4A	709779.81	278180.22	509.91	507.3
W-4B	709179.12	278154.59	508.45	507.3
W-9A	710201.35	279002.32	508.53	505.0
W-9B	710200.47	279005.20	506.20	504.9
W-10	709534.31	279085.79	505.15	504.8
W-13	709500.28	278615.70	509.38	505.5
W-14A	709519.79	279184.73	505.65	504.8
W-14B	709572.45	279145.60	507.95	504.9
W-16	709614.28	278378.10	508.69	508.3
W-15	709401.20	278816.83	509.38	506.2
W-18	709912.21	278404.41	511.60	510.1
W-22	709643.59	277618.91	505.99	503.6
W-53	709538.78	279403.39	504.97	502.7
W-27	709694.82	279122.28	504.63	504.2
W-3A	709154.39	278651.18	510.59	507.7
W-5B	709154.35	278816.70	508.72	507.6
W-C101	709352.38	279214.62	512.95	509.3
W-C102	710150.96	278278.10	509.23	506.2
W-C103	709824.98	278011.90	508.13	505.3
MW-01	709463.35	278503.07	509.55	509.6
MW-02	710191.32	279573.21	509.56	507.0

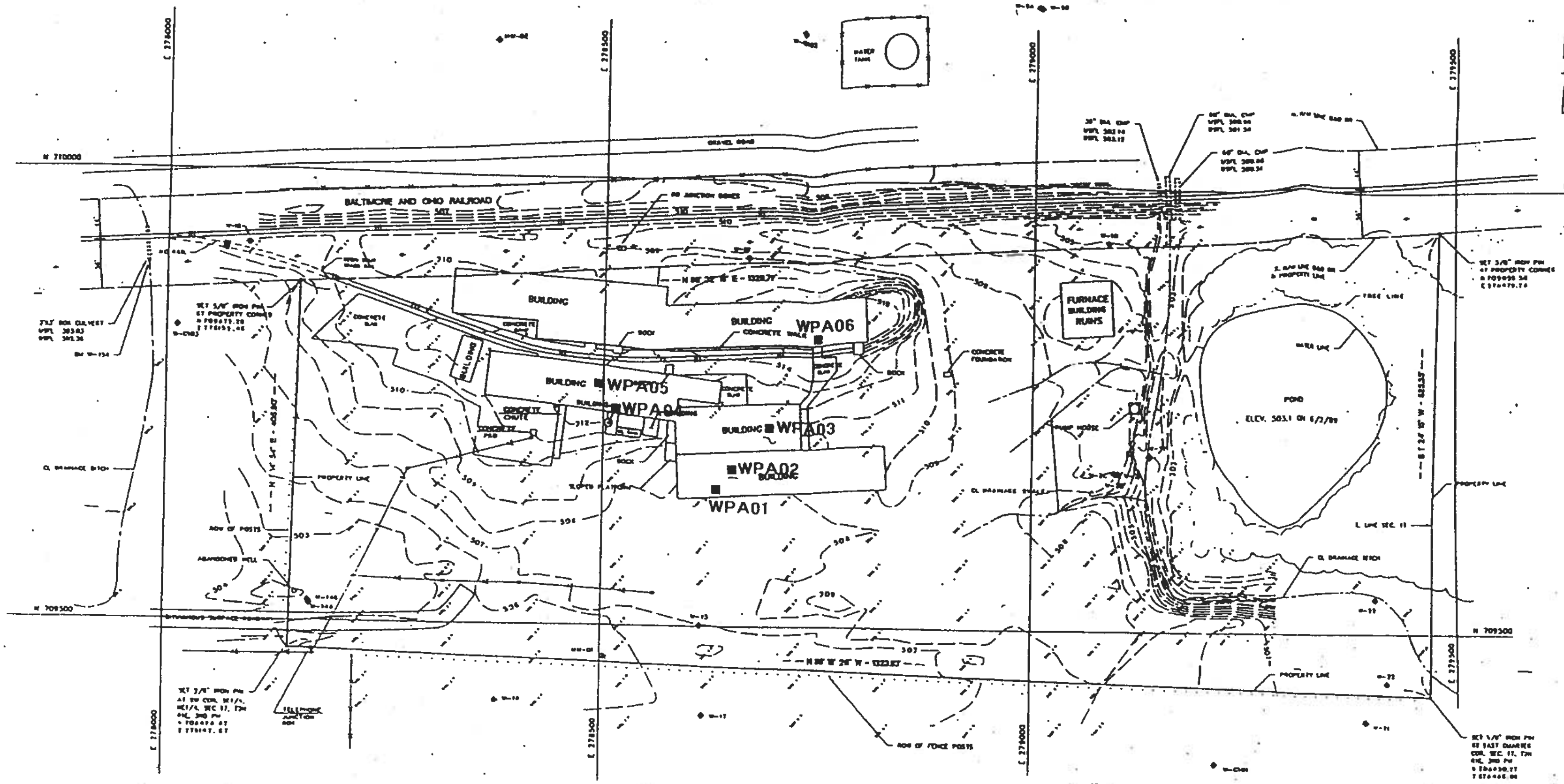
Illinois Environmental Protection Agency

Sandoval Zinc Site

Figure 2-1

Tank Sampling Location Map

EBASCO SERVICES INCORPORATED



MONITOR WELL DATA

WELL NO.	N. COORD	E. COORD	TOP CASE. ELEV.	GROUND ELEV.
W-2A	709876.58	279099.79	508.36	507.7
W-2B	709876.67	279097.85	508.31	507.8
W-2C	709876.88	279095.39	508.55	508.1
W-4A	709778.81	278680.72	509.01	507.3
W-4B	709178.12	278156.39	508.45	507.3
W-9A	710201.35	279002.37	508.57	505.9
W-9B	710200.47	279005.20	508.20	504.6
W-10	709936.31	279085.79	507.12	504.6
W-13	709500.78	278615.70	509.38	507.7
W-14A	709519.79	278766.72	507.83	501.7
W-14B	709372.45	279105.60	507.87	504.8
W-16	709914.28	278278.10	508.88	506.3
W-17	709401.20	278618.45	509.38	506.7
W-18	709812.21	278688.41	511.04	510.4
W-22	709442.98	279418.84	505.98	502.8
W-32	709536.76	279403.39	504.87	502.7
W-37	709894.02	279132.78	504.62	504.2
W-3A	709154.39	278671.18	510.36	507.1
W-3B	709134.27	278816.70	508.77	507.0
W-C101	709352.38	279214.07	512.47	509.5
W-C102	710170.94	278778.10	509.77	508.7
W-C103	709874.99	278011.90	508.17	505.5
MW-01	709462.73	278808.07	509.37	508.8
MW-02	710186.72	278772.81	508.79	507.9

LEGAL DESCRIPTION

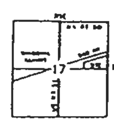
LEGEND

- POWER POLE
- COMMUNICATION POLE
- TELEPHONE JUNCTION BOX
- ELECTRIC LINE
- RAILROAD
- FENCE LINE
- MONITOR WELL

CONTOUR INTERVAL = 1'

SCALE

■ Waste Product/Ash Sample



LOCATION MAP

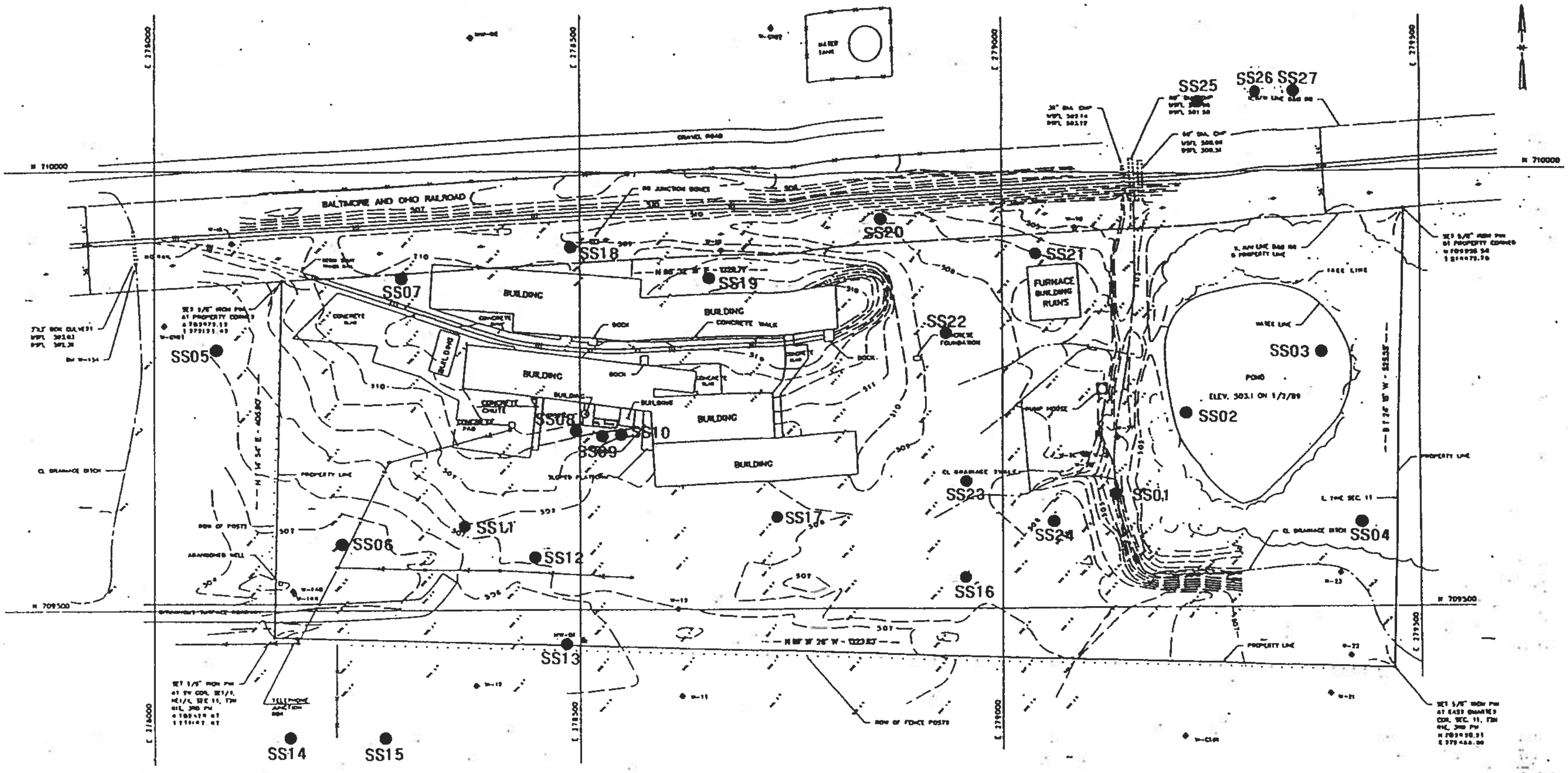
Illinois Environmental Protection Agency

Sandoval Zinc Site

Figure 2-2

Waste Product/Ash Sampling Location Map

EBASCO SERVICES INCORPORATED



MONITOR WELL DATA

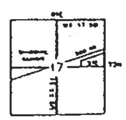
WELL NO.	N. COORD	E. COORD	TOP CASE. ELEV.	GROUND ELEV.
W-2A	709878.58	278099.78	508.36	507.7
W-2B	709878.87	278097.83	508.31	507.8
W-2C	709878.88	278095.38	508.35	508.1
W-4A	709179.87	278160.77	509.61	507.7
W-4B	709179.12	278158.58	508.45	507.3
W-8A	710201.35	279002.37	508.55	505.0
W-8B	710200.47	279005.20	506.20	504.8
W-10	709834.31	279085.79	507.17	504.8
W-12	709500.78	278615.70	509.38	507.5
W-14A	709519.70	278186.73	507.83	504.8
W-14B	709572.45	278185.60	507.65	504.5
W-16	709614.28	278379.18	508.85	508.3
W-17	709401.20	278619.83	509.38	508.7
W-18	709912.71	278484.41	511.80	518.[illegible]
W-27	709143.98	279418.44	505.96	502.8
W-22	709538.78	278403.50	504.87	502.1
W-31	709894.82	278132.78	504.87	504.3
W-5A	709134.38	278871.18	510.38	507.7
W-5B	709134.77	278818.70	506.73	507.8
W-C101	709352.38	279214.87	512.47	508.5
W-C102	710170.96	278728.10	509.23	508.3
W-C103	709874.98	278811.90	508.15	505.5
MW-D1	709483.33	278902.07	509.33	505.8
MW-D2	710181.38	278873.81	800.30	507.0

LEGAL DESCRIPTION

LEGEND
- POWER POLE
- COMMUNICATION POLE
- TELEPHONE JUNCTION BOX
- ELECTRIC LINE
- RAILROAD
- FENCE LINE
- MONITOR WELL

CONTOUR INTERVAL - 1'

SCALE



LOCATION MAP

● Surface Soil/Sediment Sample

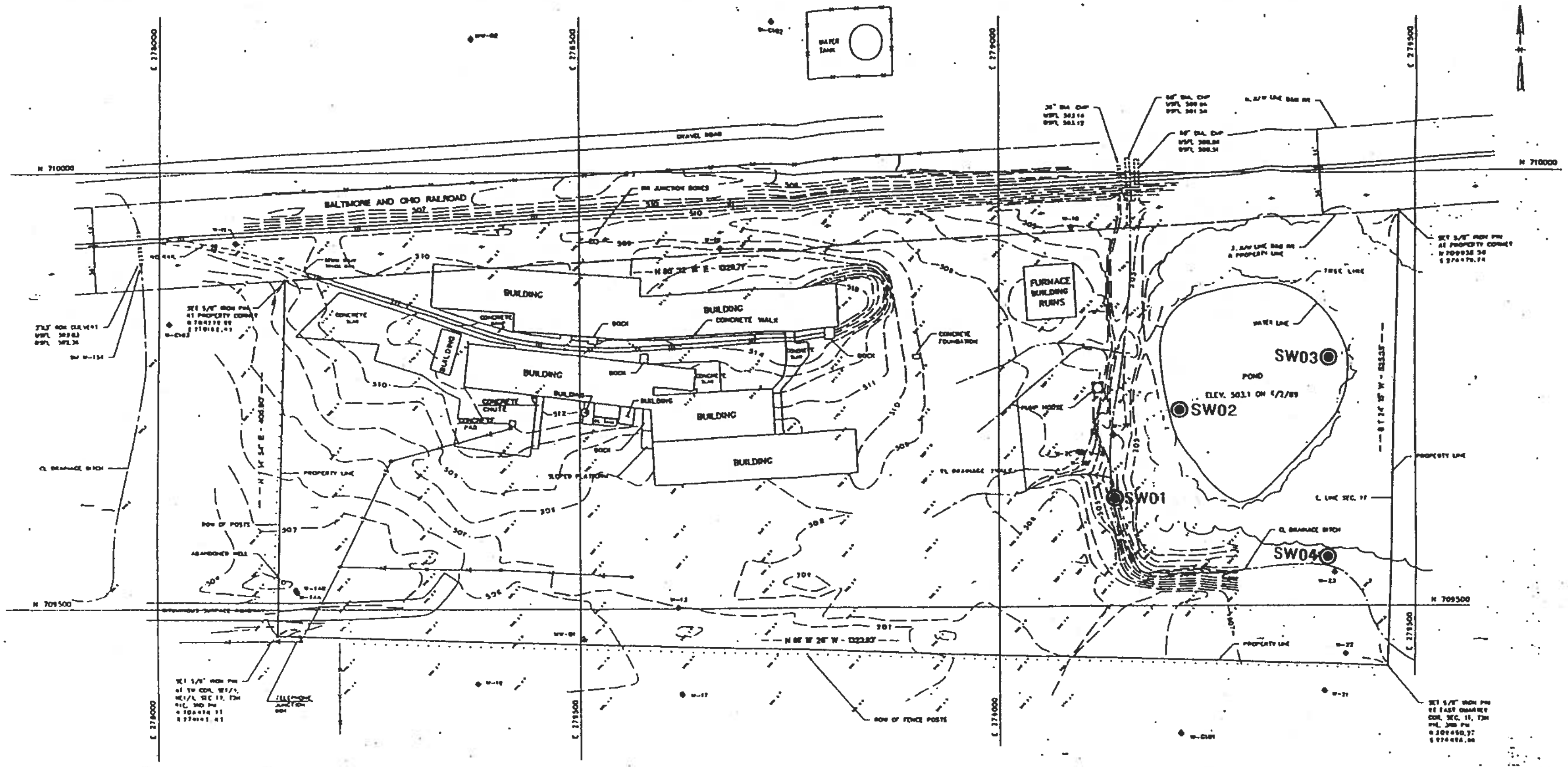
Illinois Environmental Protection Agency

Sandoval Zinc Site

Figure 2-3

Surface Soil/Sediment Sampling Location Map

EBASCO SERVICES INCORPORATED



MONITOR WELL DATA

WELL NO.	N. COORD	E. COORD	TOP CASE. ELEV.	GROUND ELEV.
W-2A	709676.38	279099.28	508.36	507.7
W-2B	709656.67	279092.85	508.51	507.9
W-2C	709676.86	279095.39	508.57	508.1
W-4A	709179.81	278180.72	509.61	507.3
W-4B	709179.12	278154.94	508.45	507.2
W-9A	710201.35	279002.32	508.75	505.8
W-9B	710200.12	279005.20	506.20	504.9
W-10	709138.31	279085.79	507.12	504.8
W-12	709500.78	278615.70	509.38	507.5
W-14A	709515.79	278108.22	507.67	504.8
W-14B	709522.45	278103.60	507.85	504.9
W-16	709114.28	278278.10	508.69	508.2
W-17	709401.20	278818.69	509.38	508.2
W-18	709812.21	278666.41	511.64	510.4
W-22	709443.90	278416.64	505.66	502.6
W-23	709538.78	278403.39	504.87	502.7
W-27	709894.12	279122.78	504.67	504.2
W-3A	709134.28	278821.18	510.38	507.7
W-3B	709134.27	278816.78	508.72	507.6
W-C101	709252.30	279214.67	512.67	509.5
W-C102	710170.96	278728.18	509.23	506.2
W-C103	709824.88	278011.90	508.15	505.3
MW-01	709482.22	278502.07	508.35	505.6
MW-02	710181.52	278373.81	508.71	507.0

LEGAL DESCRIPTION

LEGEND

POWER POLE

COMMUNICATION POLE

TELEPHONE JUNCTION BOX

ELECTRIC LINE

RAILROAD

FENCE LINE

MONITOR WELL

CONTOUR INTERVAL = 1'

SCALE

LOCATION MAP

◉ Surface Water Sample

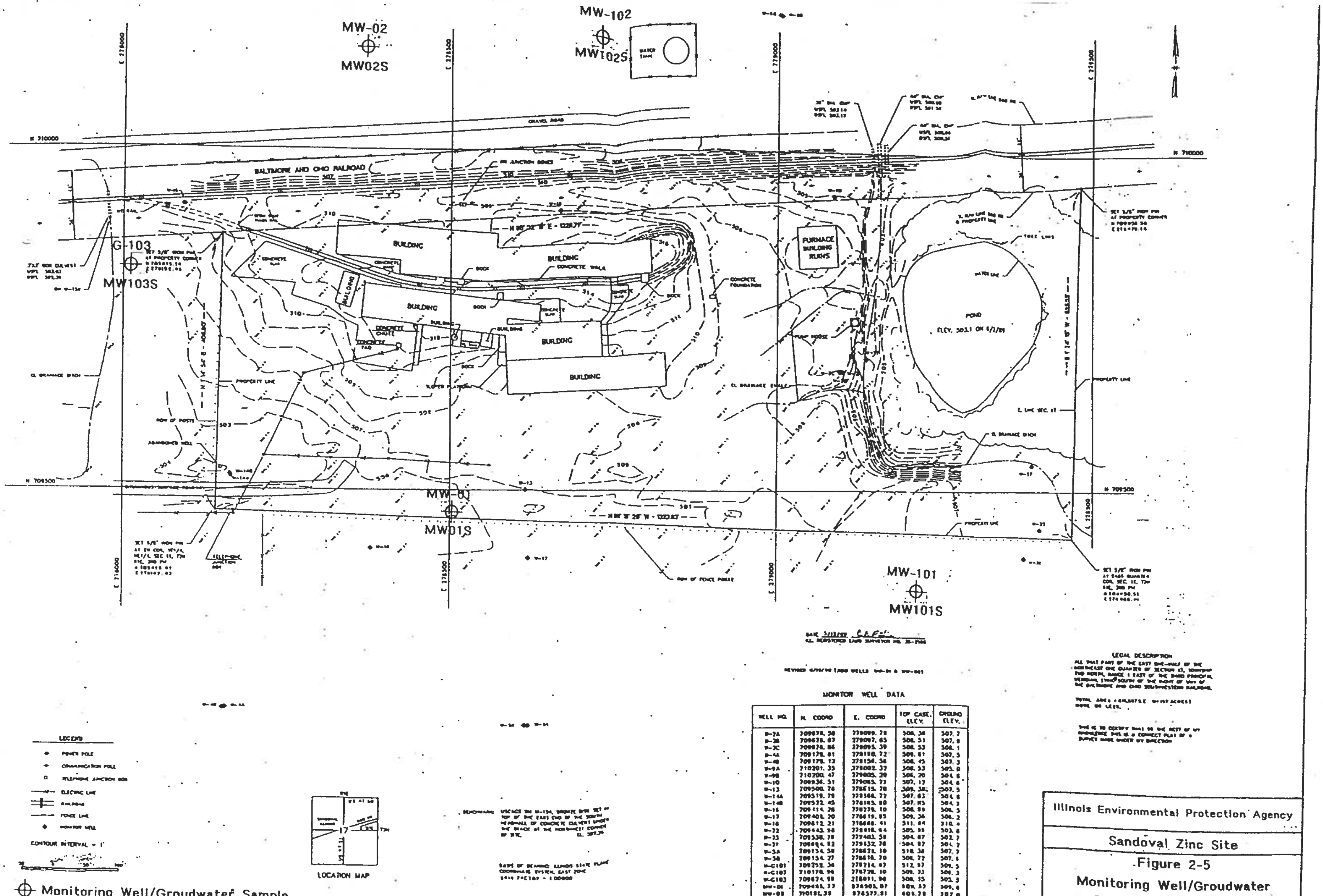
Illinois Environmental Protection Agency

Sandoval Zinc Site

Figure 2-4

Surface Water Sampling Location Map

EBASCO SERVICES INCORPORATED



MONITOR WELL DATA

WELL NO.	N. COORD	E. COORD	TOP CASE. ELEV.	GROUND ELEV.
W-2A	709678.58	279099.78	508.36	507.7
W-2B	709678.67	279097.65	508.51	507.8
W-2C	709678.86	279095.39	508.53	508.1
W-4A	709178.61	278180.72	509.61	507.5
W-4B	709178.12	278154.58	508.45	507.3
W-9A	710201.35	278002.37	508.53	505.0
W-9B	710200.47	279005.20	506.20	504.6
W-10	709936.51	279085.77	507.17	504.8
W-13	709500.78	278615.70	509.38	507.5
W-14A	709519.79	278568.77	507.63	504.6
W-14B	709522.45	278163.80	507.85	504.3
W-16	709414.28	278778.10	508.89	506.5
W-17	709401.20	278619.85	509.36	506.2
W-18	709812.21	278688.41	511.64	510.4
W-22	709443.98	278018.84	505.99	503.8
W-23	709538.78	277403.58	504.87	502.7
W-27	708894.82	279532.78	504.87	504.7
W-5A	709134.58	278628.30	510.38	507.7
W-5B	709134.27	278618.70	508.77	507.6
W-G101	709752.34	278214.67	512.97	509.5
W-G102	710170.94	278778.10	509.33	506.3
W-G103	709674.98	278011.90	508.85	505.5
MW-01	709483.77	278903.07	508.33	505.6
MW-03	710181.38	278577.81	409.78	507.0

Illinois Environmental Protection Agency

Sandoval Zinc Site

Figure 2-5

Monitoring Well/Groudwater Sampling Location Map

EBASCO SERVICES INCORPORATED

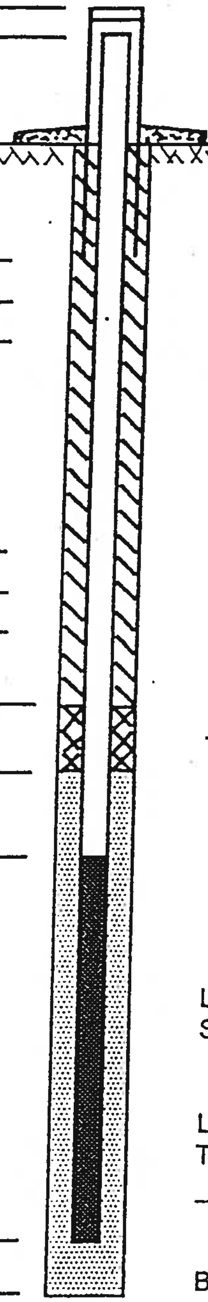
MONITORING WELL INSTALLATION

DATE: ____________________
WELL NO.: ____________________
PROJECT NO.: ____________________
PREPARED BY: ____________________
CHECKED BY: ____________________

EPTH
ELOW
GROUND
SURFACE

FT. FT.

FT.



GROUT MIX:

____
____
____

TOP OF GROUND SURFACE EL. ______ FT.
RISER PIPE EL. ________ FT.
PROTECTIVE WELL COVER CASING:

____
____
____

RISER PIPE SCHEDULE __________
ASTM DESIGNATION __________
I.D. __________ O.D. __________
COUPLINGS ____________________
PIPE IN __________ FT. LENGTHS
PIPE __________ FT.
PIPE __________ FT.
SCREEN __________ FT.
TOTAL __________ FT.

BENTONITE SEAL:

____
____
____

FT.

FT.

THICKNESS OF BENTONITE SEAL ________ FT.

FT.

LENGTH OF SCREEN __________ FT.
SLOT SIZE __________________ IN.

LENGTH OF FILTER PACK __________ FT.
TYPE OF FILTER PACK ______________
____

FT.

FT.

BOTTOM OF BORING

REMARKS: ____
____
____
____
____
____

EBASCO SERVICES INCORPORATED

Figure 2-6

Table 2-1
Monitoring Well Data
Sandoval Zinc
Sandoval, Illinois

WELL[1]	MW101	MW102	MW103	MW01	MW02
Elevation of Ground Surface (ft)	509.5	506.3	505.3	505.8	507
Elevation of Top of Casing (ft)	512.67	509.23	508.15	509.33	509.33
Depth to Top of Formation (ft)	11.2	12.2	12.3	12.5	14.4
Depth to Water (6/28/90) (ft)	7.34	4.74	4.74	4.44	4.42
Depth to Top of Screen (ft)	11.7	12	12	10.76	13.35
Elevation of Piezometric Surface (ft) (6/28/90)	505.33	504.49	504.42	504.89	504.96
Elevation of Top of Screen (ft)	497.8	494.3	493.3	495.04	493.65
Elevation of Top of Formation (ft) (Hagerstown)	498.3	494.1	493.3	495.04	492.6
Well Completion Data	4/06/87	4/08/87	4/06/87	6/14/90	6/15/90

1 - 5 foot screen

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section presents the physical characteristics of the study area based on available literature, data from previous investigations, and the additional field activities conducted by EBASCO for the IEPA. Special emphasis was given to those features needed to characterize the site for use in evaluating and selecting remedial alternatives.

3.1 Demography and Land Use

The Sandoval Zinc site is located southeast of the City of Sandoval in Marion County, Illinois (Figure 3-1). The 1980 census records list the total population of Marion County at 41,561, yielding an estimated 75 people per square mile in the county. The 1980 census also indicates that the population of Sandoval, Illinois was 1,535 people; this extrapolates to approximately 240 people living within a 1-mile radius of the Sandoval Zinc site.

The land area in the immediate vicinity of the Sandoval Zinc site is used for a variety of purposes. The land immediately south of the site is farmland, and the land north of the site is undeveloped grassland. West of the site, along Route 51, are several small businesses, and adjacent to Sandoval Zinc on the west is a junkyard and scrap metal yard. During the field investigations of May and June 1990, several piles of trash and tires in the junkyard appeared to be smoldering. There are marshy areas on the eastern and western edges of the site, and building refuse and scrap are littered across the site.

3.2 Topography

Marion County is located in south-central Illinois in the physiographic region known as the Springfield Plain (ISGS, 1975). The land surface has been modified by glacial activity into the relatively flat to gently rolling plains characteristic of glacial drift regions. Surface elevations in the county range from approximately 475 to 520 feet above mean sea level (MSL).

The topography in the vicinity of the site is relatively flat and lies at approximately 500 to 505 feet MSL. An artificial mound of cinder and other fill material has raised the elevation of the central part of the site to approximately 510 feet MSL. The surface elevation of the farm pond at the eastern site boundary was surveyed in 1989 at 503.1 feet MSL. The site surface slopes gently to the lower elevations on all sides, except to the east, where a rapid drop of about 5 to 8 feet occurs, down to the farm pond. A topographic map with ground surface elevations at the one-foot contour interval is shown in Figure 3-2.

3.3 Surface Water

The Sandoval Zinc site is located within the Prairie Creek drainage basin. Prairie Creek, which is the nearest surface water body in the vicinity of the site (Figure 3-1), flows to the south west about one half mile south of the site. Approximately six miles south-southeast of the Sandoval Zinc site is the Centralia Reservoir and Crooked Creek.

Surface water runoff at the site is controlled by site topography and the existing drainage ditches to the east and west. Since the central part of the site is the highest topographically due to the artificial fill, surface water runoff is in all directions away from the buildings. Surface water drains into both ditches, but primarily into the eastern ditch near the farm pond. Runoff from the site likely carrys material south, away from the site and into the neighboring field.

3.4 Geology

3.4.1 Regional Geology

The Sandoval Zinc site is located in the south central portion of the Illinois Basin, a large Paleozoic spoon-shaped sedimentary basin. Surficial deposits overlying the bedrock strata of the basin are unconsolidated glacial tills, outwash, and drift. The thickness and composition of these glacial deposits vary across the state, typically thinning to the south (Willman et al., 1975)[5]. Figure 3-3 is a generalized stratigraphic column of Pennsylvanian and younger sediments of south central Illinois.

The glacial deposits of south central Illinois are composed primarily of till, poorly sorted clay, silt, sand, and pebbles laid down during the four major Pleistocene advances of the glaciers (the Nebraskan, Kansan, Illinoisan, and Wisconsinan glacial advances). The periods of time between the glacial advances were known as the interglacials, and were times of soil formation (the Aftonian, Yarmouthan, and Sangamonian interglacials).

The Nebraskan and Kansan glacial advances represent the first two episodes of Pleistocene glaciation in Illinois. The Nebraskan glacial advance effected a small portion of western Illinois and was either never deposited in south central Illinois or subsequently eroded. In areas where Nebraskan glacial deposits occur it is common to find the Afton Soil formed on top of the deposits. The Kansan glacial advance effected nearly two-thirds of Illinois. Sediments deposited during the Kansan glacial advance in south central Illinois belong to the Banner Formation Till and the Lierle Clay Member overlies the till of the Banner Formation. The Yarmouth Soil was developed directly on top of the Kansan glacial deposits during Yarmouthian time. The Lierle Clay units is part of the Yarmouth Soil but is an accretionary deposit made largely throughout Yarmouthian time (Willman et al., 1975).

The Illinoisan stage was marked by three major glacial advances into which covered most of the state. The Glasford Formation Till was deposited during the first and second glacial events of the Illinoisan stage. The Vandalia Till Member of the Glasford Formation was deposited during the second glacial event of the Illinoisan stage since the ice sheet stopped well north of south central Illinois during the final phase of glaciation. The Hagarstown Member of the Glasford Formation was then deposited. The Berry Clay Member of the Glasford Formation has been identified as a Sangamon accretion gley (Willman and Frye, 1970)[6]. Sagamon Soil developed directly on top of the Illinoisan deposits.

There were two glacial advances during the Wisconsinan stage. Wisconsinan glacial deposits were limited to northern Illinois, with large quantities of loess deposited over much of the rest of the state. Roxana Silt, a loess was deposited during the early and middle Wisconsinan during the first of the two glacial advances. The Farmdale Soil was a result of an interval of soil formation between the two Wisconsinan advances. Peoria Loess was then deposited as the result of deflation of alluvial deposits from outwash streams of late Wisconsinan glaciers.

The regional framework of bedrock strata in Illinois is controlled by the Illinois Basin. Strata underlying the study site range from Pre-Cambrian granites (oldest) to Pennsylvania sedimentary layers (youngest). The strata generally strike northeast and dip and thicken to the southeast, towards the center of the basin. The Pre-Cambrian basement rocks in Illinois are granites and granodiorites. They lie at depths greater than 8,000 feet below the ground surface in Marion County, and deep well investigations have shown up to several hundred feet of variation in the surface layer of these Pre-Cambrian rocks.

The preglacial bedrock surface in Marion county, Illinois belongs to the Pennsylvanian Bond Formation. These Pennsylvanian rocks consist predominantly of green calcareous clays and shales interbedded with thin sandstone, limestone, and coal layers. The Bond Formation varies from less than 150 feet thick in eastern Illinois to over 300 feet in southeastern Illinois and is approximately 250 feet thick in much of Marion County.

3.4.2 Site Geology

The subsurface geology at the Sandoval Zinc site was interpreted from EBASCO boring logs and previously existing boring logs of the IEPA. Two generalized cross sections were constructed from these logs. The locations of the cross-sections are shown in Figure 3-4. One cross-section was north-south (Figure 3-5), and the other was east-west (Figure 3-6).

The depths and thicknesses of the subsurface strata indicated were generalized from and interpreted between the borings. Information on actual subsurface conditions exists only at the locations of the well borings. Monitoring well boring logs and well construction diagrams can be found in Appendix B.

The generalized stratigraphy at the site, beneath the artificial cinder fill, consists of glacial deposits of varying thickness overlying the Pennsylvanian Bond Shale. From the EBASCO and IEPA boring logs, the glacial deposits, to depths of approximately 20 feet below ground surface, consist of the Peoria Loess and the Roxana Silt of the Wisconsinan Glacial Stage; the Berry Clay of the Sangamonian Stage; and the Illinoisan Stage Hagarstown Member and the Glasford Till. The Peoria Loess is a brownish-grey clayey silt with small amounts of sand (ISWS/ISGS, 1982) that was formed by wind deposits of fine particulate matter. The loess ranges in thickness from 6 to 12 feet across the Sandoval Zinc site. The Roxana Silt is described as a dark brown clayey silt with a fair percentage (20-34%) of sand. The Roxana Silt is thin underneath the site, thickness range from 1 to 2 feet. The Berry Clay is distinguished from the overlying silt by its dark-grey color and texturally it is a sandy, silty clay with some gravel (ISWS/ISGS, 1982). The Hagarstown Member of the Illinoisan Stage is a thin (1 to 2 foot) silty sand, that is variable in both thickness and composition; at times it is difficult to distinguish from the underlying till. The Hagarstown is the only unit which is water-bearing in the vicinity of the site. The Glasford Till consists of grey to dark grey sandy and silty till. Small lenses of sand, silt, and clay can be found within the till, which has thicknesses of approximately 20 to 40 feet.

Previous investigations by the ISWS/ISGS determined the glacial deposits below the Glasford Till to be the Lierle Clay and the Banner Formation Till. Underlying the Banner Formation Till, at depths of 55 to 75 feet below ground surface is the Pennsylvanian Bond Formation, a micaceous green shale. The EBASCO and IEPA borings were shallower than the borings of the ISWS/ISGS study, and were also located at the edges of the site, where the artificial fill material was not encountered.

3.5 Groundwater

3.5.1 Regional Groundwater

Much of the regional groundwater in Marion County, especially in the western portion of the county, is retrieved from the unconsolidated glacial deposits that cover the Pennsylvanian bedrock. In limited areas, Pennsylvanian sandstones are a source of groundwater, especially in the southeastern portion of the county. Where the sandstones occur, groundwater can be recovered from the top 150 to 200 feet of the units (ISGS, 1957).

A buried valley is present in the west central part of Marion County. The pre-glacial valley has thick deposits of unconsolidated materials, especially sand and gravels. Buried valleys in the county to the west of Marion County is also a potential source of private and municipal water supplies.

3.5.2 Local Groundwater

3.5.2.1 Groundwater Availability

Most of the local water supply for the City of Sandoval and the surrounding farms is obtained from large-diameter wells completed in the unconsolidated deposits of the Hagarstown Member. These wells, which were either dug or bored, usually tapped lenses on thin layers of water-bearing silt sand or gravel only a few inches thick (ISWS, 1980). The wells range in depth from 30 to 60 feet and water levels may vary up to 10 feet due to seasonal precipitation and recharge changes. These wells typically produce only a few hundred gallons of water a day and offer no potential for providing a municipal supply. Test holes drilled into the underlying shale bedrock have yielded only a few thin beds of water-yielding sandstone and creviced limestone. Below depths of 100 to 150 feet, the water is likely to be too brackish for domestic use.

3.5.2.2 Groundwater Elevation

Water level data from the EBASCO and IEPA monitoring wells completed in the Hagarstown Member are presented in Table 3-1. Figure 3-7 presents the groundwater elevation in Hagarstown Member based on the average water levels measured from May 1990 and June 1990. It appears the groundwater in the Hagarstown Member is under confined or semiconfined conditions. The general direction of groundwater flow in the Hagarstown is somewhat difficult to determine. In 1975 and 1976, the ISWS/ISGS study discovered that the groundwater formed a mound under the Sandoval Zinc site, a mound centered on the site buildings. It was thought at that time that the mound existed due to liquid disposal practices at the site during operation and the high permeability of the fill material.

Water level elevations taken during the field investigation in May and June 1990 were taken only from five wells. Many of the wells of the ISWS/ISGS study were either not located or found to be unusable. Water level data collected during this investigation is insufficient to determine the presence or absence of the groundwater mound reported in 1975 and 1976.

3.5.2.3 Hydraulic Conductivity

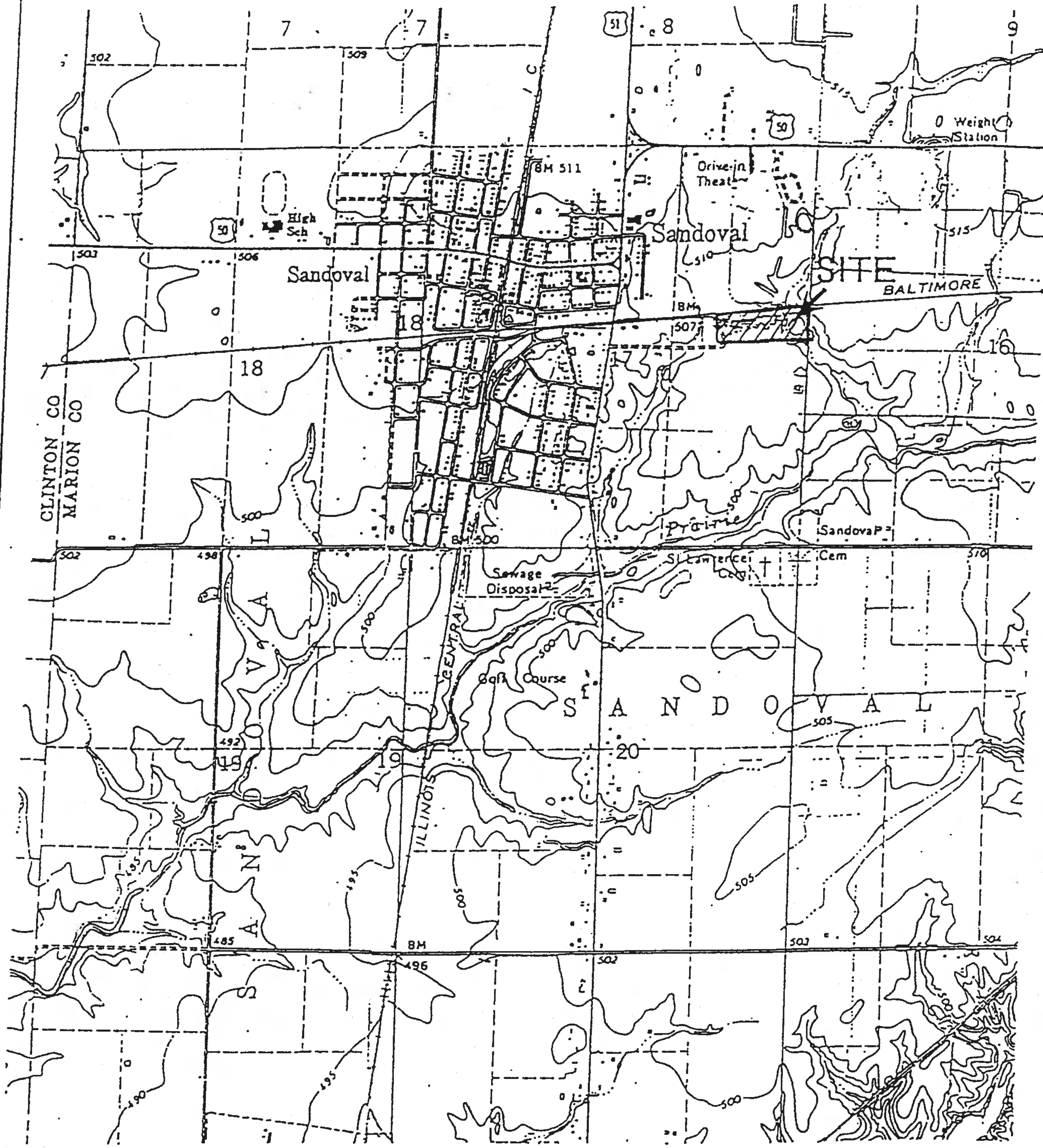
The hydraulic conductivity (permeability) of the Hagarstown Member was determined from the slug tests conducted at the newly installed EBASCO monitoring wells (MW01 and MW02) and at the IEPA monitoring wells (MW101, MW102, MW103)

Slug tests consisting of falling and rising head tests were conducted on the wells in May and June 1990. Falling head slug tests were performed by instantaneously lowering a 4-1/2 foot long, 1-1/4 inch O.D. stainless steel slug attached to a nylon rope into the monitoring well until it was fully submerged. The water level drop was measured at timed intervals and recorded using a pressure transducer and data logger. Rising head slug tests consisted of quickly pulling the slug out of the well and recording the subsequent water level rise.

The hydraulic conductivity of the Hagarstown Member in the vicinity of the screened interval was calculated using the Hvorslev method for confined conditions (Hvorslev, 1957)[7]. The calculated hydraulic conductivity of the unit ranged from 2.2 to 4.9 ft/day (7.8×10^{-4} to 1.7×10^{-3} cm/s). Previous values reported for the Hagarstown ranged from 8.3×10^{-3} to 9.1×10^{-3} cm/sec (ISWS/ISGS, 1982). These values of hydraulic conductivity are consistent with the wide range of values reported in the literature for unconsolidated silty to clean sand (Freeze and Cherry, 1979)[8]. The slug test data and the hydraulic conductivity calculations are presented in Table 3-2.

3.5.2.4 Groundwater Velocity

According to Darcy's law, groundwater velocity is a function of hydraulic conductivity and hydraulic gradient. Since the hydraulic gradient cannot be determined due to the uncertainty of the groundwater flow direction in the Hagarstown Member, at present, the groundwater velocity cannot be estimated.



⌖ Residential Well Location
Inorganic Concentrations in ug/l

SCALE 1:24000

1000 0 1000

CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL

N

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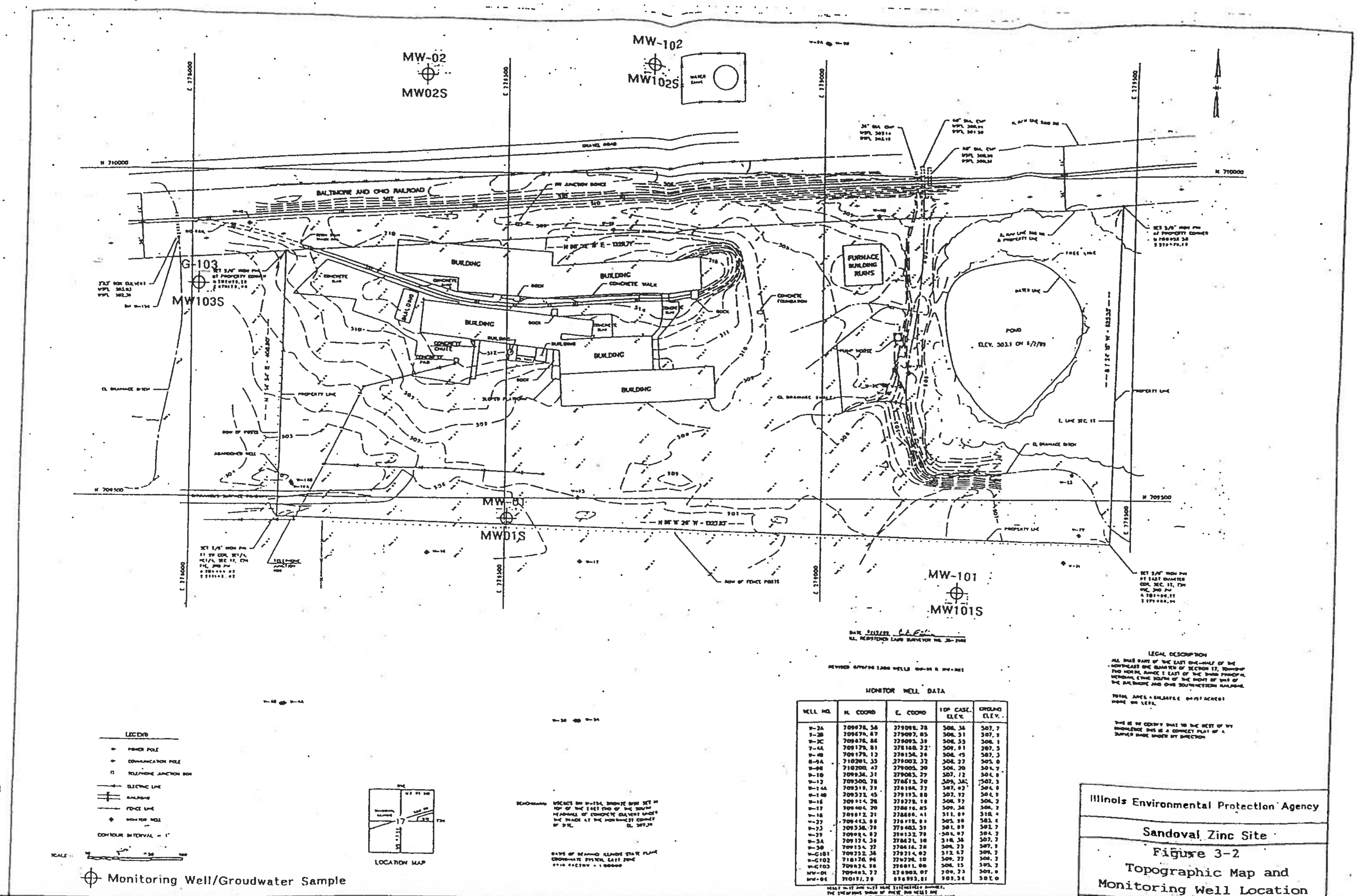
Sandoval Zinc Site
Figure 3-1 Site Location Map



WELL NO.	N. COORD	E. COORD	TOP CASE. ELEV.	GROUND ELEV.
W-2A	709678.38	279098.28	308.36	307.7
W-2B	709674.67	279097.85	308.51	307.8
W-2C	709676.84	279093.30	308.55	308.1
W-4A	709179.81	278180.22	309.01	307.5
W-4B	709179.12	278154.26	308.45	307.3
W-9A	710201.33	279002.32	308.27	305.0
W-9B	710200.47	279005.30	306.20	305.7
W-10	709934.31	279085.27	307.12	306.8
W-12	709500.78	278615.20	309.38	307.3
W-14A	709519.73	278184.77	307.07	306.8
W-14B	709522.45	279153.88	307.37	306.8
W-16	709114.28	278278.18	308.57	306.2
W-17	709404.20	278616.85	309.38	308.7
W-18	709812.21	278600.41	311.09	310.4
W-27	709413.00	278118.01	305.56	303.6
W-23	709538.70	278403.55	301.03	302.7
W-33	709994.02	278132.78	305.07	304.7
W-3A	709174.30	278621.10	310.38	307.7
W-3B	709154.77	278616.78	309.73	307.8
W-G101	709752.38	279714.02	312.67	309.7
W-G102	710170.96	279778.10	309.77	308.7
W-G103	709874.36	278011.08	308.15	305.7
MW-01	709403.77	278903.07	309.73	305.0
MW-02	710171.70	278933.81	303.36	302.0

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Sandoval Zinc Site

Figure 3-2
Topographic Map and Monitoring Well Location

STAGE	UNIT
WISCONSINAN	PEORIA LOESS
	ROXANA SILT
SANGAMONIAN	BERRY CLAY MEMBER- GLASFORD FORMATION
ILLINOIAN	HAGARSTOWN MEMBER- GLASFORD FORMATION
	GLASFORD FORMATION TILL
YARMOUTHIAN	LIERLE CLAY MEMBER- BANNER FORMATION
KANSAN	BANNER FORMATION TILL
PENSYLVANIAN SYSTEM	BOND FORMATION

(After Willman et al., 1975)

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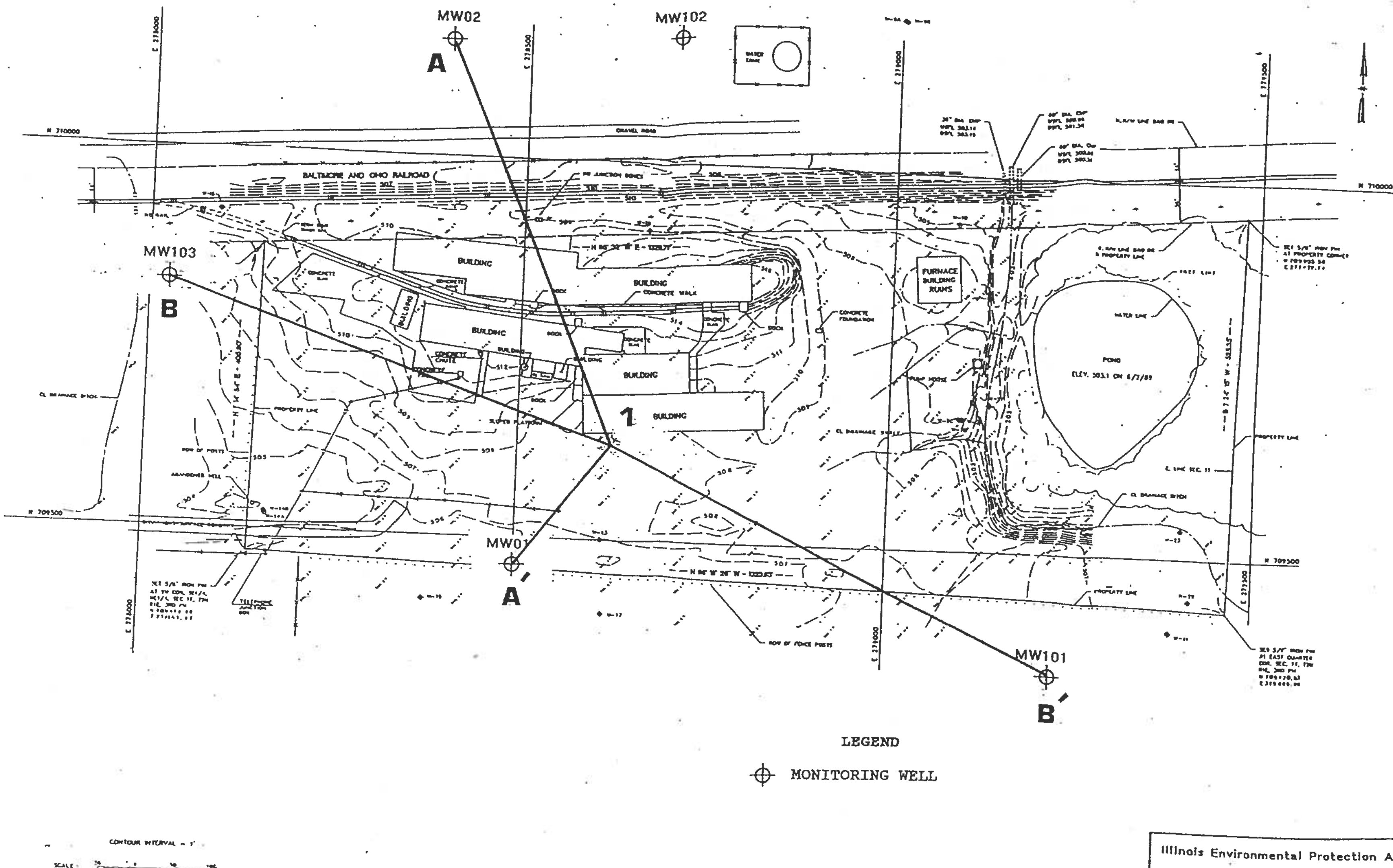
Sandoval Zinc Site

Figure 3-3
Generalized Stratigraphic
Column



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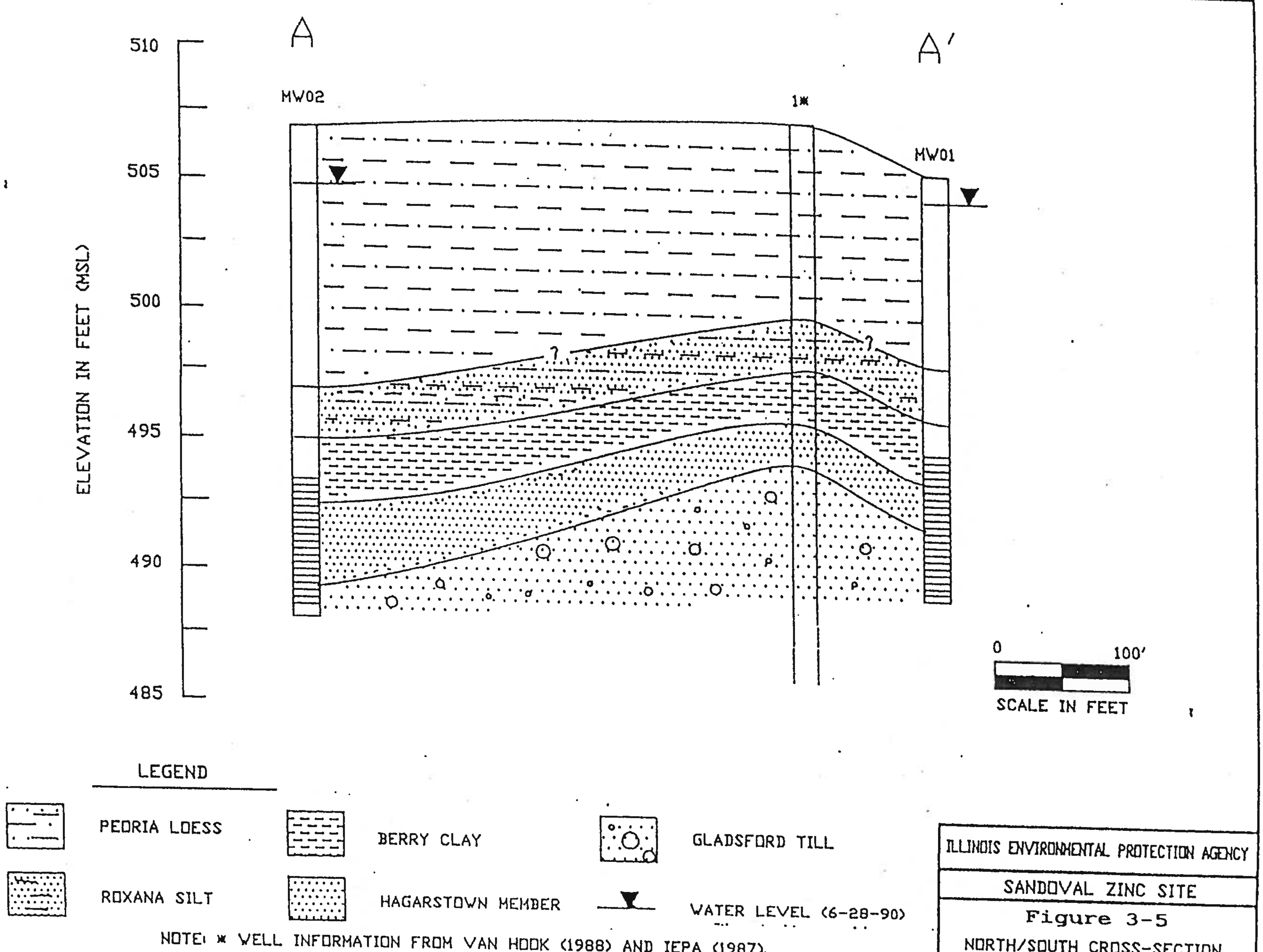
Sandoval Zinc Site

Figure 3-4
Generalized Geologic



ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

SANDOVAL ZINC SITE

Figure 3-5

NORTH/SOUTH CROSS-SECTION

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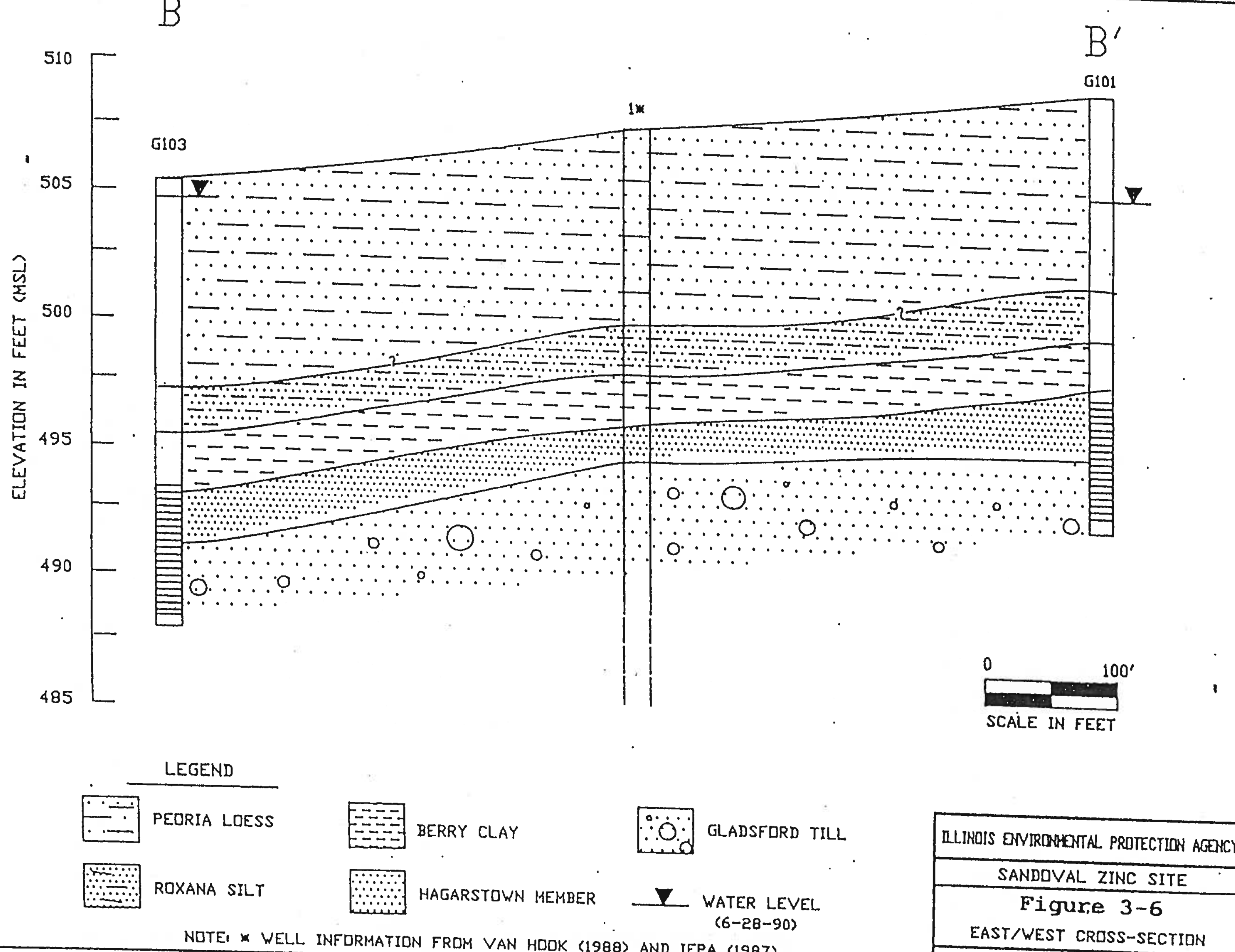


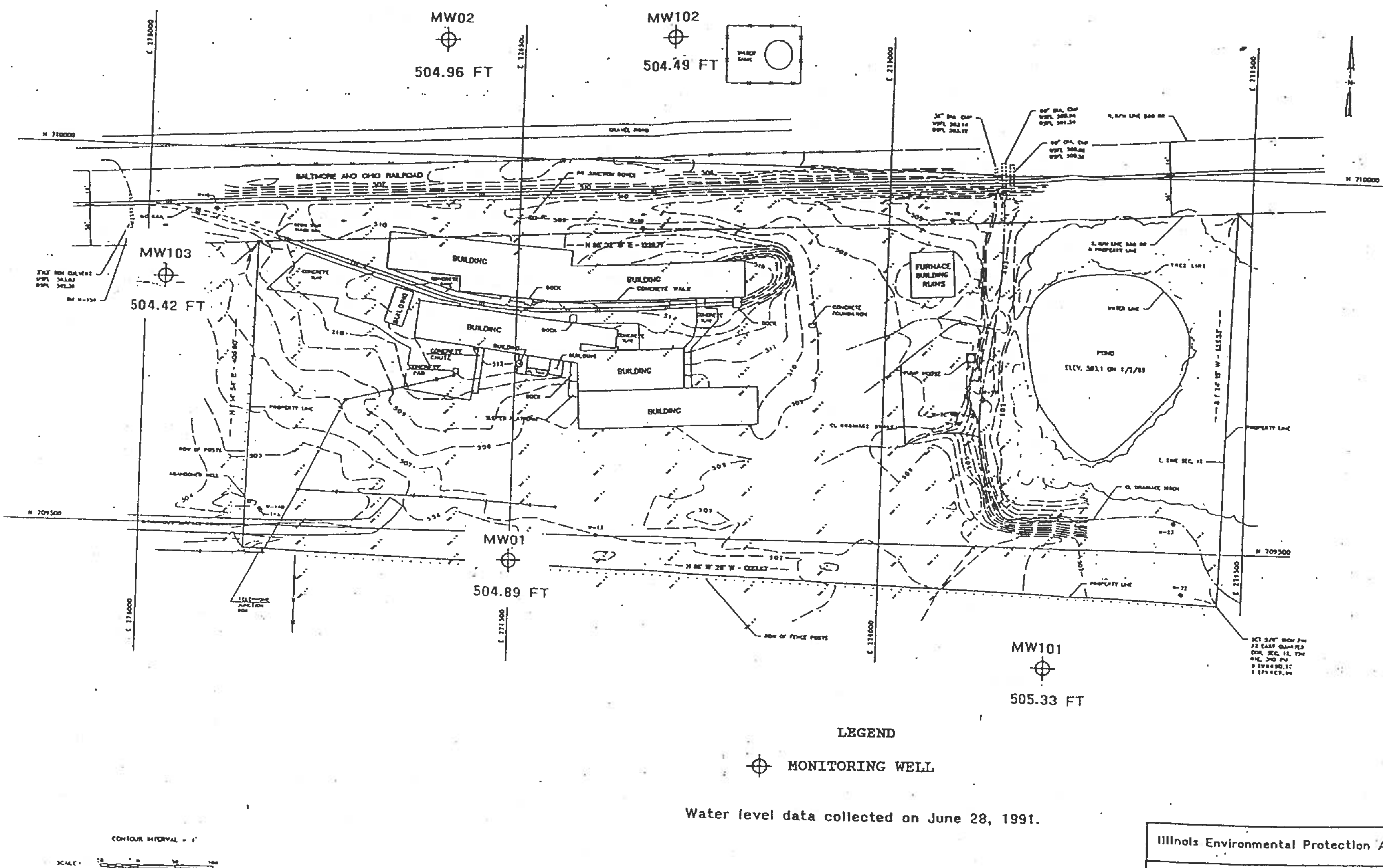
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY

SANDOVAL ZINC SITE

Figure 3-6

EAST/WEST CROSS-SECTION

EBASCO SERVICES INCORPORATED



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Sandoval Zinc Site

Figure 3-7
Monitoring Well
Water Level Elevations

Table 3-1
Monitoring Well Data
Sandoval Zinc
Sandoval, Illinois

WELL[1]	MW101	MW102	MW103	MW01	MW02
Elevation of Ground Surface (ft)	509.5	506.3	505.3	505.8	507
Elevation of Top of Casing (ft)	512.67	509.23	508.15	509.33	509.33
Depth to Top of Formation (ft)	11.2	12.2	12.3	12.5	14.4
Depth to Water (6/28/90) (ft)	7.34	4.74	4.74	4.44	4.42
Depth to Top of Screen (ft)	11.7	12	12	10.76	13.35
Elevation of Piezometric Surface (ft) (6/28/90)	505.33	504.49	504.42	504.89	504.96
Elevation of Top of Screen (ft)	497.8	494.3	493.3	495.04	493.65
Elevation of Top of Formation (ft) (Hagerstown)	498.3	494.1	493.3	495.04	492.6
Well Completion Data	4/06/87	4/08/87	4/06/87	6/14/90	6/15/90

1 - 5 foot screen

Note: IEPA monitoring wells G101, G102, and G103 were renamed for use in this report to MW101, MW102, and Mw103, respectively.

Table 3-2
Slug Test Analyses and
Hydraulic Conductivity Calculations

Confined Conditions K=A/FT=d*d*In(2L/D+(1+2L/D)*(2L/D))^0.5)/(8*L*T)

Well Number	Riser Diameter (D) (inches)	Borehole Diameter (D) (inches)	Length of Water Intake (L) (ft)	Basic Lag Time (T) (min)	Hydraulic Conductivity (K) (ft/day)
* MW101	2	10.25	1.3	2.5	2.80E+00
* MW102	2	10.25	2.7	2.1	2.23E+00
* MW103	2	10.25	2	2.3	2.42E+00
MW01	2	10.25	2.5	1.5	3.26E+00
MW02	2	10.25	3.6	0.8	4.87E+00

* IEPA monitoring wells G101, G102, and G103 were renamed for use in this report to MW101, MW102, and MW103, respectively.

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents a discussion of the analytical results, by sample media, for all samples collected during the field investigation at the Sandoval Zinc site. Detailed analytical results for all the samples are presented in Appendix C.

4.1 Above Ground Storage Tank

One sample and a duplicate were collected from the abandoned above ground storage tank (Figure 4-1). The samples were analyzed for Target Analyte List (TAL) inorganics, PCBs, and the volatile organic compounds benzene, toluene, ethyl benzene, and xylene (BTEX). The samples were also analyzed for their heating value. Five inorganic and three organic compounds were detected in the tank sample and in the duplicate. Iron, lead, nickel, vanadium, and zinc were all detected at concentrations under 50 ppm. Toluene, ethyl benzene, and xylenes were also detected in the tank sample and duplicate. Toluene values were 4,400 ppb and 6,700 ppb in the sample and duplicate; ethyl benzene was detected at 20,000 ppb and 23,000 ppb, and xylene at 96,000 ppb and 92,000 ppb. No PCBs were detected in either the tank sample or the duplicate. The heating values of the sample and duplicate were 18,500 and 17,800 btu/lb., respectively. The analytical result are summarized in Table 4-1.

4.2 Product/Ash

Six samples and one duplicate were collected from the piles of waste product and ash within the main building at the site (Figure 4-2). The samples were analyzed for full TAL inorganics and for EP Toxicity. Aluminum, iron, lead, and zinc were detected in concentrations greater than 10,000 mg/kg in at least two of the samples. Aluminum concentrations were greater than 10,000 mg/kg in five of the six samples and in the duplicate. Zinc concentrations were greater than 200,000 mg/kg in all samples and duplicate, except for sample WPA06S, where the level of zinc was 27,000 mg/kg. Other metals detected in relatively high concentrations were chromium, copper, and nickel, but they were found only in a random scattering across the samples. EP Toxicity results from the samples of waste product and ash varied from sample to sample. The maximum concentration levels permitted in the extract from EP Toxicity tests were exceeded in all samples for barium, cadmium, chromium, and lead, but the highest concentrations were found in samples WPA02S, WPA03S, WPA05S, and WPA06S.

Table 4-2 summarizes the key results for the inorganic analysis and the EP Toxicity test. The concentration levels for the EP Toxicity test are the legal limits for leachable metals.

All samples failed to meet the specified levels for one or more metals. Therefore, the waste product and ash must be considered hazardous waste.

4.3 Surface Soil

Twenty-three surface soil samples and three duplicate samples were collected from the locations shown in Figure 4-3. All the samples were analyzed for full TAL inorganics. Two of the samples, SS08S and SS10S, and the duplicate SS10D were also analyzed for PCBs. Aluminum, calcium, copper, iron, lead, and zinc were found in high concentrations in most samples. Concentrations of aluminum were typically greater than 5,000 ppm in the surface soil samples. Iron, lead, and zinc levels were found to be greater than 10,000 mg/kg in most samples and copper concentrations were typically above 1,000 mg/kg. Other metals that were detected at elevated levels in several samples include antimony, cadmium, chromium, manganese, mercury, nickel, and silver. No PCBs were detected in SS08S, SS10S, or SS10D. Table 4-3 shows a summary of the key analytical results for the surface soil samples.

4.3.1 Comparison of Results with Previous Investigation

A publication entitled "Retention of Zinc, Cadmium, Copper, and Lead By Geologic Materials" prepared by the Illinois State Water Survey (ISWS) and the Illinois State Geological Survey (ISGS) documents an investigation conducted at the Sandoval Zinc site from 1974 to 1977. The purpose of this investigation was to define the vertical and horizontal migration patterns of zinc, cadmium, copper, and lead through the soil and shallow aquifer systems at Sandoval Zinc and one other secondary zinc smelting site.

During the present field investigation, lead, zinc, copper, and nickel were detected in high concentrations in surface soil samples. Cadmium and silver were also detected but in relatively lower concentrations. The ISWS/ISGS study did not analyze soil samples for silver and nickel. Figure 4-3 shows the location of the surface soil samples collected in the present study along with concentrations of lead, zinc, copper, silver, and nickel in the samples. For comparison, Table 4-4 indicates the approximate concentrations of lead, zinc, cadmium, and copper obtained from selected well and core samples in the ISWS/ISGS study. The locations of these samples are shown in Figure 4-4 and are approximate since the ISWS/ISGS report did not use surveyed site maps to show sample locations. The ISWS/ISGS study did not analyze all core samples for the same parameters. Consequently, different ISWS/ISGS samples are compared to the same samples from the EBASCO study for specific analytes in Tables 4-4 and 4-5. The purpose of comparison between ISWS/ISGS data on metals concentration in surface soil, and the data compiled by EBASCO is to determine if site conditions have changed significantly since the ISWS/ISGS study.

In general, the data on surface soil samples in the EBASCO study are in the same range with those obtained in the ISWS/ISGS study. However, the exact concentrations of the laboratory analysis for the metals in the previous study are unknown. Therefore, EBASCO cannot be certain as to whether or not contaminants have migrated from the surface. Furthermore, the previous study did not analyze for silver which is found in concentrations significantly higher than those found in the average soils (0.01-5 mg/kg) throughout the United States. The silver could have come from the zinc ores mined from southern Missouri and smelted at the facility.

4.4 Surface Water

Four surface water samples and one duplicate were collected from the locations shown in Figure 4-1. The samples were analyzed for volatile organic compounds (BTEX) and for full TAL inorganics. The only volatile organic compound detected was toluene, but since toluene was also found in the laboratory blank, the compound could be due to laboratory contamination. Inorganic analytes detected in the surface water samples at elevated concentrations include aluminum, cadmium, calcium, copper, iron, magnesium, manganese, nickel, silver, thallium, and zinc (Table 4-6).

4.5 Groundwater

Two shallow monitoring wells were installed on-site. The wells were screened in the Hagarstown Member. Groundwater elevations in the two newly installed monitoring wells and the three existing wells on-site were measured on June 28, 1990. Water level data are insufficient to draw a contour map due to the small differences in elevations between the monitoring wells. It appears that the piezometric surface of the groundwater in the Hagarstown Member is relatively flat, so no determination of the hydraulic gradient or the groundwater velocity at the site could be made. Slug tests performed on the wells during the field investigation yielded hydraulic conductivity values ranging from 8.8×10^{-4} to 2.8×10^{-3} cm/sec for the Hagarstown Member.

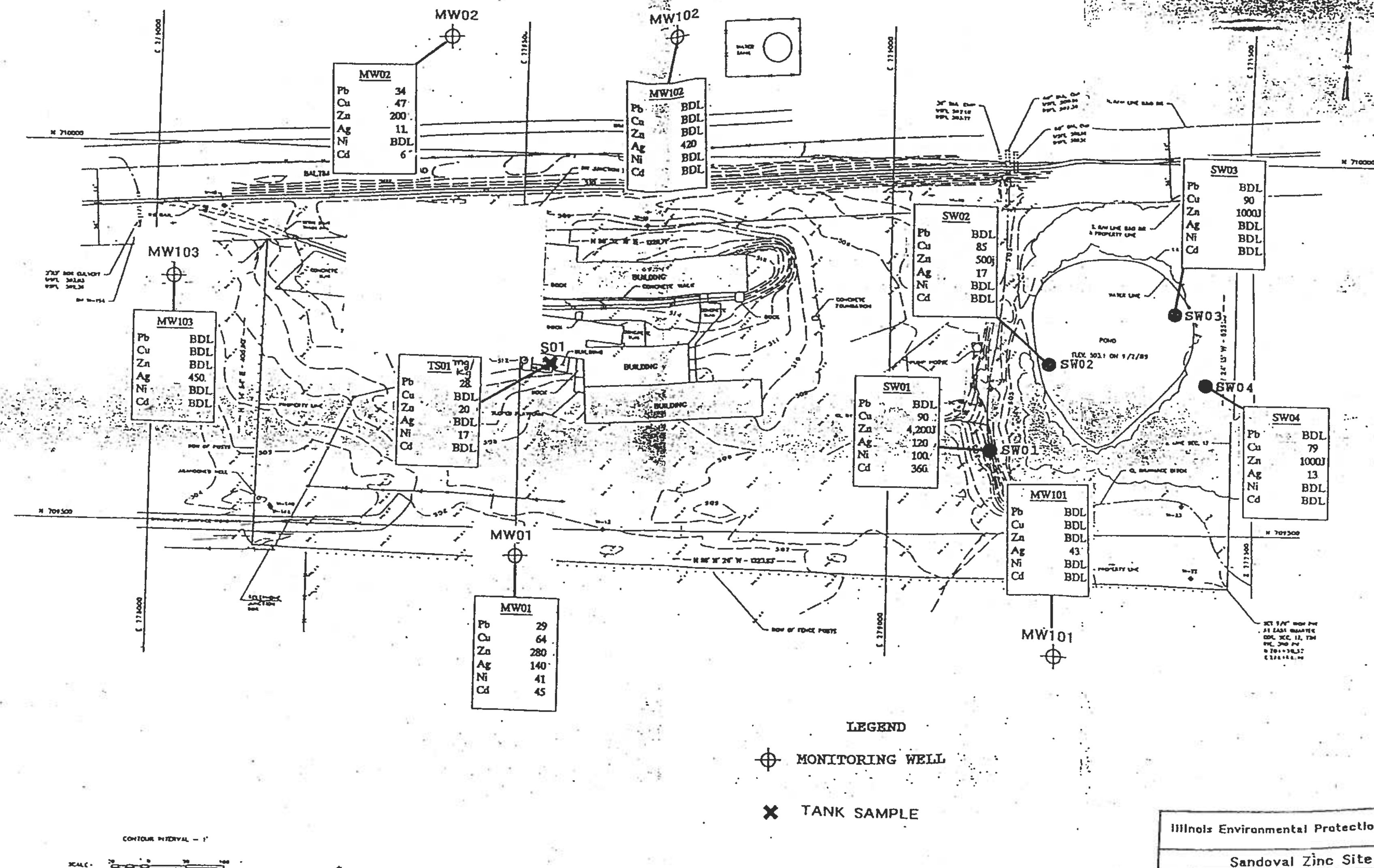
Six groundwater samples and two duplicate samples were collected from five wells on-site (Figure 4-1) and from a single residential well (Figure 1-1, Residential Well A). Residential wells B&C were not sampled because they could not be identified. All samples were analyzed for full TAL inorganics; the samples collected from the five monitoring wells on-site were also analyzed for PCBs and BTEX. Two of the groundwater samples, MW102S and MW103S, were also analyzed for the full TCL organics list. None of the groundwater samples contained PCBs, nor did they contain any volatile organic compounds, with two exceptions (Table 4-7). Groundwater samples MW01S and MW103S both contained trace amounts (less than 5 μg/l) of toluene.

Of the twenty-three metals analyzed, calcium, magnesium, potassium, and sodium were detected at levels greater than 1,000 μg/l in most samples. These concentrations are most likely due to the bedrock and soil composition and are probably unrelated to past site activities. Aluminum, cadmium, chromium, iron, manganese, silver, thallium, and zinc were also detected in most of the groundwater samples. The residential groundwater sample and the duplicate contained iron (2,660-2,700 μg/l), manganese (160 μg/l) silver (60-61 μg/l), thallium (100 μg/l) and zinc 88-96 μg/l). Silver and thallium in the residential well samples exceeded Federal Drinking Water Standards values of 50 μg/l and 0.5 μg/l, respectively. The groundwater samples collected from MW01 and MW02 exceeded Federal Drinking Water Standards for cadmium, chromium, copper, and silver. Table 4-8 summarizes the groundwater quality data. The high values of calcium (24,000-1,100,000 μg/l) and magnesium (8,370-360,000 μg/l) indicate that these constituents were most likely released from the soil into the groundwater through ion-exchange with the contaminant metals on-site. So long as the soil has adequate ion-exchange capacity, the calcium and magnesium levels in the groundwater are likely to remain high.

4.6 Sediment

Sediment samples (SS01 through SS04) were collected from the four locations shown in Figure 4-3. Four samples and one duplicate were collected and analyzed for TAL inorganics and PCBs. High concentrations of aluminum, cadmium, copper, iron, lead, manganese, nickel, silver, and zinc were detected in all the sediment samples. Aluminum, iron, and zinc were found in concentrations generally greater than 10,000 mg/kg. The remaining detected metals were generally in the greatest concentrations in sediment samples SS01S, SS01D, and SS04S. No PCBs were detected in any of the sediment samples. Table 4-9 summarizes the key results from the analyses.

Although the sediment samples were not analyzed for EP Toxicity, the high levels of lead detected in the samples suggest that the sediments would be classified as a characteristic hazardous waste.



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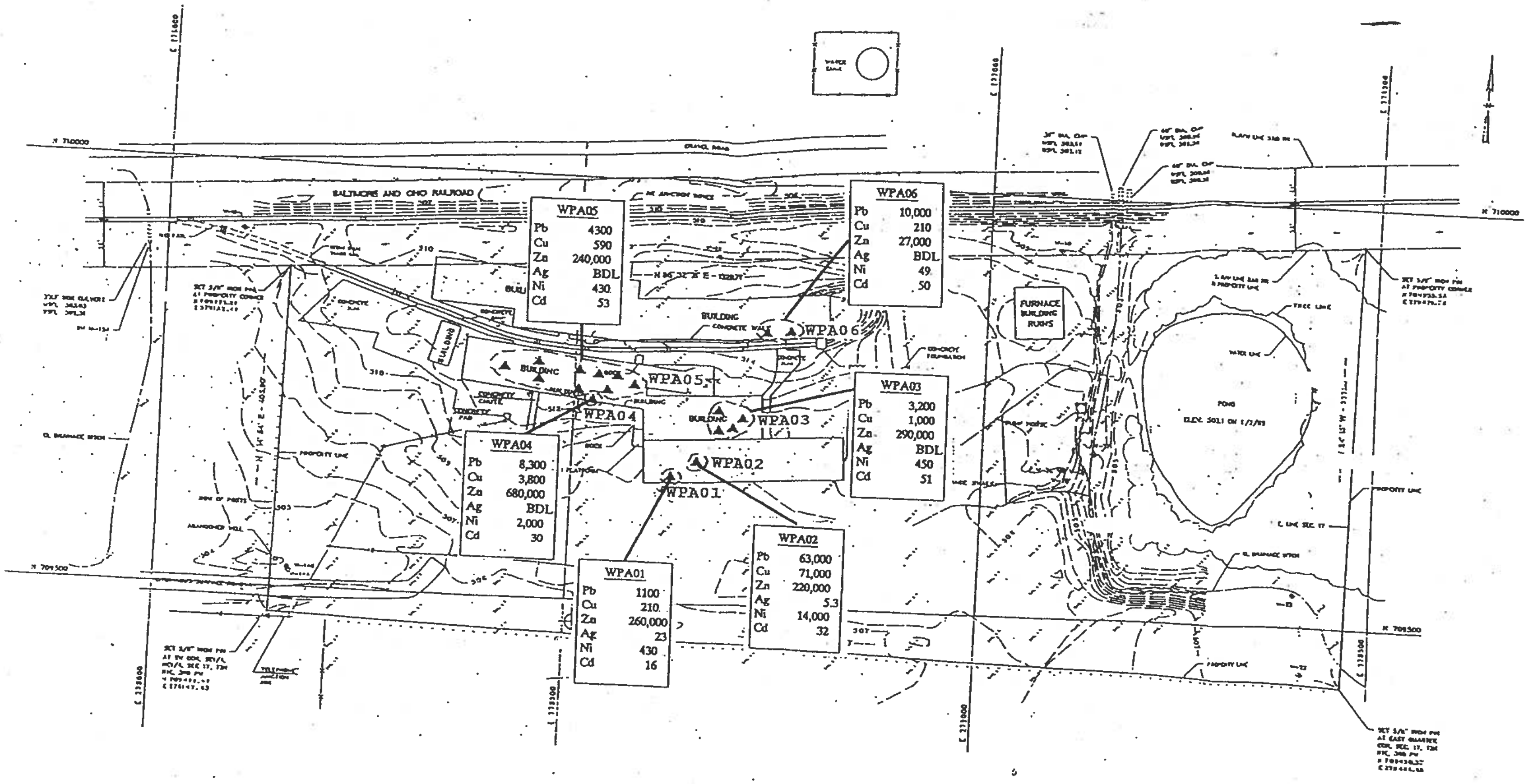
Sandoval Zinc Site

Figure : 4-1
Inorganic Concentrations (ug/l)
In Monitoring Well, Surface
Water and Tank Samples



LEGEND

▲ WASTE PILE SAMPLE

(▲) COMPOSITE WASTE PILE SAMPLE

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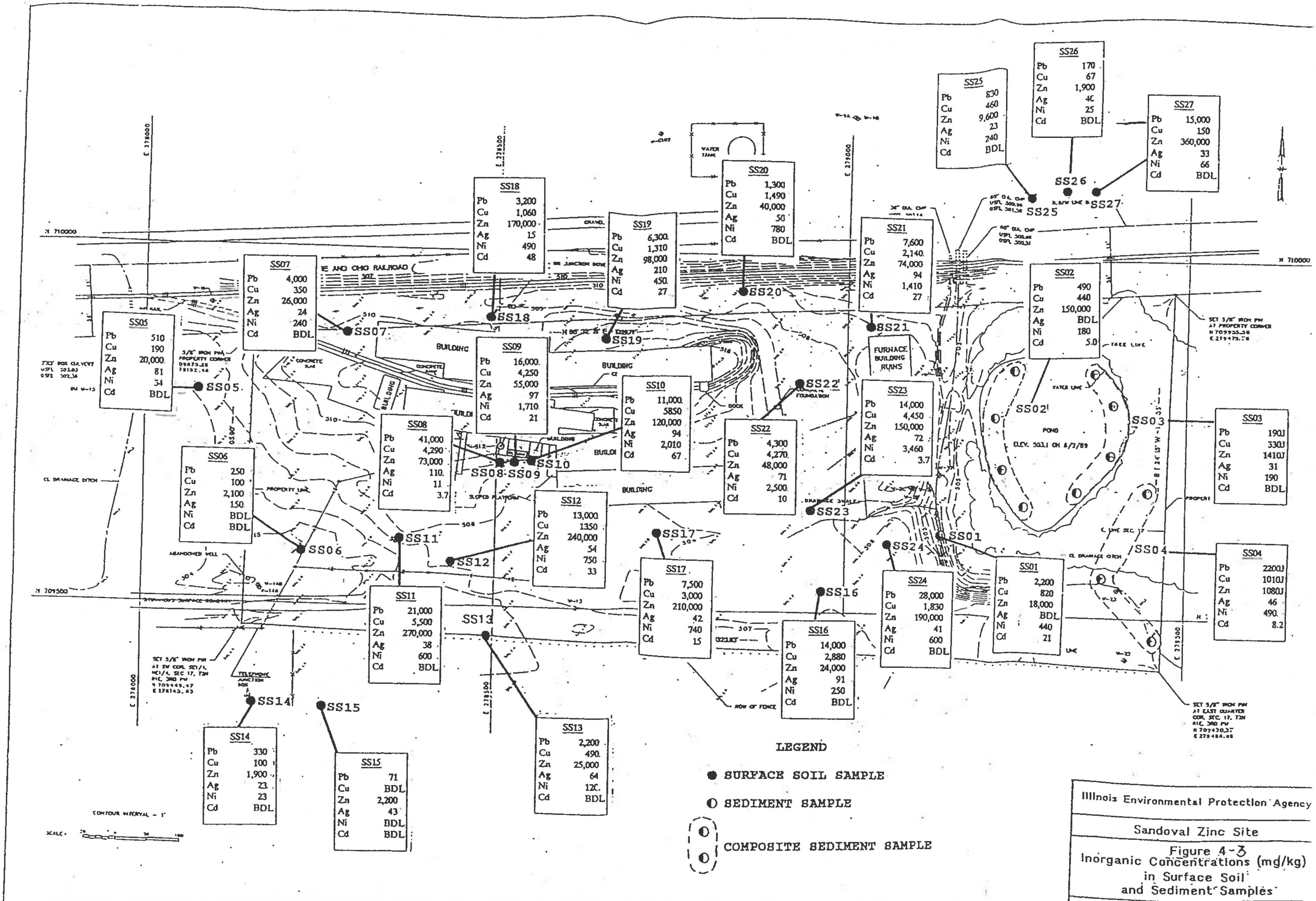
Sandoval Zinc Site

Figure 4-2
Inorganic Concentrations (mg/kg) in Waste Pile and Composite Waste Pile Samples



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Sandoval Zinc Site

Figure 4-3
Inorganic Concentrations (mg/kg) in Surface Soil and Sediment Samples

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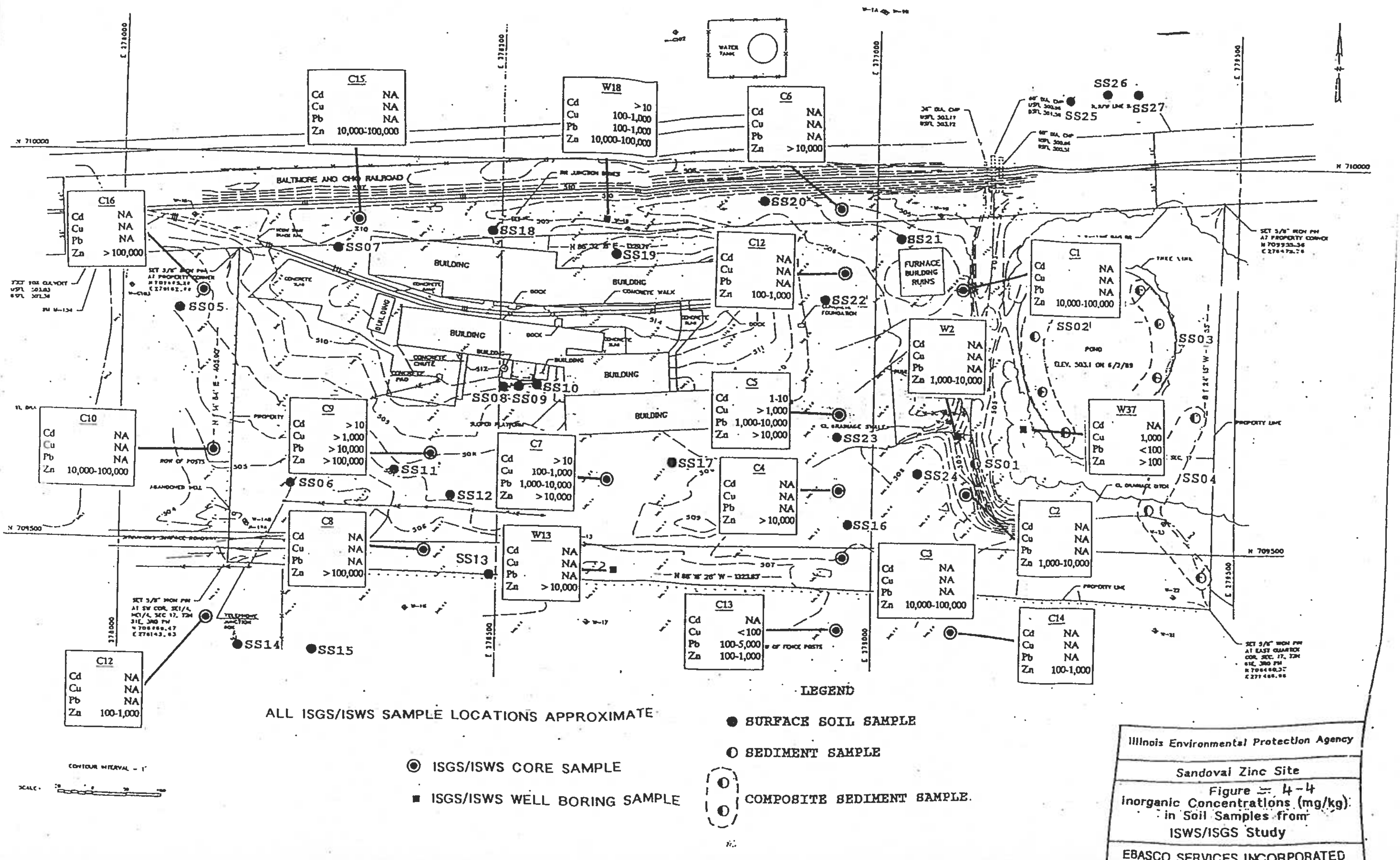

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Sandoval Zinc Site

Figure 4-4
Inorganic Concentrations (mg/kg) in Soil Samples from ISWS/ISGS Study

EBASCO SERVICES INCORPORATED

TABLE 4-1: SUMMARY OF ANALYTICAL RESULTS FROM TANK SAMPLES

Analysis	Sampling Locations		
	CRDL	TS01S	TS01D
Inorganic Compounds (mg/kg)			
Iron	100	41	34
Lead	5	28	28
Nickel	40	17	17
Vanadium	50	49	46
Zinc	20	20	19
Volatile Organics (μg/kg)			
Toluene	1.0	4400.J	6700.
Ethylbenzene	5.0	20,000.	23,000.
Xylenes (Total)	10.0	96,000.	92,000.
Heating Value (BTU/lb)		18,500	17,800

CRDL = Contract Required Detection Limits
S = Sample
D = Duplicate
J = Estimated Value

TABLE 4-2: SUMMARY OF ANALYTICAL RESULTS FROM WASTE PRODUCT AND ASH SAMPLES

	Sampling Locations							
Analysis	CRDL	WPA01S	WPA01D	WPA02S	WPA03S	WPA04S	WPA05S	WPA06S
Inorganic Compounds (mg/kg)								
Aluminum	200.0	74,000	79,000	37,000	27,000	10,000	15,000	1,800
Chromium	10	330	300	330	110	40	55	1.9U
Copper	25	210	160	71,000	1,000	3,800	590	210
Iron	100	87,000	94,000	22,000	24,000	2,300	62,000	3,200
Lead	5	1,100	1,000	63,000	3,200	8,300	4,300	10,000
Nickel	40	430	450	14,000	450	2,000	430	49
Zinc	20	260,000	260,000	220,000	290,000	680,000	240,000	27,000
EP Toxicity Values (μg/l)	MCL							
Barium	100.0	260	290	4,000	1,000	160	760	1,200
Cadmium	1.0	250	270	200	880	340	1,500	210
Chromium	5.0	10	8.6	8.7	6.9	12	7.2	6.2
Lead	5.0	12	43	4,000	8,400	22,000	46,000	7,100

CRDL = Contract Required Detection Limits
MCL = Maximum Concentration Levels
S = Sample
D = Duplicate
U = Compound Analyzed for But Not Detected

TABLE 4-3: SUMMARY OF INORGANIC ANALYSES (MG/KG) IN SURFACE SOIL SAMPLES

	Sampling Locations									
Analyte	CRDL	SS05S	SS05D	SS06S	SS07S	SS08S	SS09S	SS10S	SS10D	SS11S
Aluminum	200.0	11,300	11,000	7,520	6,000	6,770	8,990	7,160	7,400	11,500
Antimony	60	2.8U	2.2U	15U	15	28	16	23	17	61
Cadmium	5	1.4U	1.3U	1.2U	1.1U	3.7	21	67	35	1.5U
Calcium	5,000	10,900	3,500	96,800	14,300	1,830	3,430	4,570	2,440	1,640
Chromium	10	2.8U	5.1	2.4U	24	9.5	16	98	18	60
Copper	25	190	73	100	350	4,290	4,250	5,850	3,770	5,500
Iron	100	36,300	19,700	14,900	18,500	75,200	69,700	70,300	58,900	26,900
Lead	5	510	130	250	4,000	41,000	16,000	11,000	6,200	21,000
Manganese	15	240	190	260	220	94	170	380	350	180
Mercury	0.2	0.47	0.10U	0.11	1.0	0.22	0.45	0.21	0.19	2.1
Nickel	40	34	44	9.7U	240	11	1,710	2,010	2,710	600
Silver	10	81	47	150	24	110	97	94	83	38
Zinc	20	20,000	4,200	2,100	26,000	73,000	55,000	120,000	88,000	270,000

CRDL = Contract Required Detection Limits
S = Sample
D = Duplicate
R = Rinsate
J = Estimated Value
U = Compound Analyzed for But Not Detected

TABLE 4-3: SUMMARY OF INORGANIC ANALYSES (MG/KG) (Cont'd.) IN SURFACE SOIL SAMPLES

Analyte	Sampling Locations										
	CRDL	SS12S	SS12R	SS13S	SS13D	SS14S	SS14R	SS15S	SS16S	SS16R	SS17S
Aluminum	200.0	11,800	200U	12,900	10,300	8,600	200U	11,100	10,400	200U	8,810
Antimony	60	19	60U	13U	2.4U	2.6U	60U	2.2U	150	60U	25
Cadmium	5	33	5U	1.1U	1.2U	1.0U	5U	1.2U	1.0U	5U	15
Calcium	5,000	1,800	1,000UJ	2,030	990	980	1,000UJ	630	5,210	1,000UJ	1,580
Chromium	10	27	15	2.2	2.3U	2.0U	10	2.4U	24	10U	17
Copper	25	1,350	53	490	520	100	35	6.0U	2,880	25	3,000
Iron	100	35,300	66J	36,500	42,100	15,900	50UJ	22,300	57,600	64J	37,400
Lead	5	13,000	52	2,200	2,200	330	5U	71	14,000	37	7,500
Manganese	15	550	15U	1,150	1,360	400	15U	2,320	410	15U	400
Mercury	0.2	49	0.20U	0.37	1.1	0.069U	0.20U	0.059U	0.37	0.20U	13
Nickel	40	750	40U	120	110	23	40U	9.5U	250	40U	740
Silver	10	54	10U	64	67	23	10U	43	91	10U	42
Zinc	20	240,000	3,200	25,000	21,000	1,900	440	2,200	24,000	100	210,000

CRDL = Contract Required Detection Limits
S = Sample
D = Duplicate
R = Rinsate
J = Estimated Value
U = Compound Analyzed for But Not Detected

TABLE 4–3: SUMMARY OF INORGANIC ANALYSES (MG/KG) (Cont'd.) IN SURFACE SOIL SAMPLES

Analyte	Sampling Locations										
	CRDL	SS18S	SS19S	SS20S	SS21S	SS22S	SS23S	SS24S	SS25S	SS26S	SS27S
Aluminum	200.0	6,130	6,530	7,770	10,700	7,310	6,540	5,710	8,910	9,630	6,750
Antimony	60	65	240	12U	280	210	180	60	6.6	2.6U	2.4U
Cadmium	5	48	27	1.0U	27	10	3.7	1.3U	1.4U	1.4U	1.0U
Calcium	5,000	4,180	23,500	1,670	29,200	2,090	4,500	750	960	480	1,270
Chromium	10	13	73	4.4	8.3	14	16	2.6U	2.7U	2.7U	2.0U
Copper	25	1,060	1,310	1,490	2,140	4,270	4,450	1,830	460	67	150
Iron	100	5,380	126,000	32,100	56,600	44,600	54,100	43,200	16,300	21,000	18,400
Lead	5	3,200	6,300	1,300	7,600	4,300	14,000	28,000	830	170	15,000
Manganese	15	340	3.5U	4.2	320	120	290	13	390	1,790	910
Mercury	0.2	1.4	5.7	0.45	0.66	0.53	0.46	7.7	0.11	0.098U	0.081U
Nickel	40	490	450	780	1,410	2,500	3,460	600	240	25	66
Silver	10	15	210	50	94	71	72	41	23	40	33
Zinc	20	170,000	98,000	40,000	74,000	48,000	150,000	190,000	9,600	1,900	360,000

CRDL = Contract Required Detection Limits
S = Sample
D = Duplicate
R = Rinsate
J = Estimated Value
U = Compound Analyzed for But Not Detected

TABLE 4–4: SUMMARY OF SURFACE SOIL ANALYTICAL DATA
(All Concentrations in mg/kg)

LEAD				ZINC				COPPER			
Ebasco Study		ISGS Study		Ebasco Study		ISGS Study		Ebasco Study		ISGS Study	
Sample #	Concentration	Sample #	Concentration	Sample #	Concentration	Sample #	Concentration	Sample #	Concentration	Sample #	Concentration
Background:	71–15,000	Background:	10–40	Background:	1,900–360,000	Background:	20–50	Background:	6–460	Background:	10–30
SS14	330			SS14	1,900	C12	100–1,000	SS14	100		
SS15	71			SS15	2,200			SS15	6.0U		
SS25	830			SS25	9,600			SS25	460		
SS26	170			SS26	1,900			SS26	67		
SS27	15,000			SS27	360,000			SS27	150		
SS01	2,200	C37	<100	SS01	18,000	W2	1,000–10,000	SS01	820	C37	1,000
SS02*	490			SS02*	150,000	C1	10,000–100,000	SS02*	440		
SS03*	190J			SS03*	1,410J			SS03*	330J		
SS04*	2,200J			SS04*	1,080J			SS04*	1,010J		
SS05	510	W3	100–1,000	SS05	20,000	C6	10,000	SS05	190	W3	<100
SS06	250			SS06	2,100			SS06	100		
SS07	4,000			SS07	26,000	C15	10,000–100,000	SS07	350		
SS08	41,000			SS08	73,000			SS08	4,290		
SS09	16,000			SS09	55,000			SS09	4,250		
SS10	11,000			SS10	120,000			SS10	5,850		
SS11	21,000	C9	>10,000	SS11	270,000	C19	>100,000	SS11	5,500	C9	>1,000
SS12	13,000			SS12	240,000			SS12	1,350		

* Composite of 3 Grab Samples

TABLE 4–4: SUMMARY OF SURFACE SOIL ANALYTICAL DATA (Cont'd.)
(All Concentrations in mg/kg)

LEAD				ZINC				COPPER			
Ebasco Study		ISGS Study		Ebasco Study		ISGS Study		Ebasco Study		ISGS Study	
Sample #	Concentration	Sample #	Concentration	Sample #	Concentration	Sample #	Concentration	Sample #	Concentration	Sample #	Concentration
SS13	2,200	C13	100-5,000	SS13	25,000	W13	>10,000	SS13	490	C13	<100
SS16	14,000			SS16	24,000	C8	>100,000	SS16	2,880		
SS17	7,500	C7	1,000-10,000	SS17	210,000	C4	10,000-100,000	SS17	3,000	C7	100-1,000
SS18	3,200			SS18	170,000	C7	>10,000	SS18	1,060		
SS19	6,300	W18	100-1,000	SS19	98,000	W18	10,000-100,000	SS19	1,310	W18	100-1,000
SS20	1,300			SS20	40,000	C6	10,000-100,000	SS20	1,490		
SS21	7,600			SS21	74,000	C10, C1	10,000-100,000	SS21	2,140		
SS22	4,300			SS22	48,000	C12	10,000-100,000	SS22	4,270		
SS23	14,000	C5	1,000-10,000	SS23	150,000	C5	10,000-100,000	SS23	4,450	C5	>1,000
SS24	28,000			SS24	190,000	C2	1,000-10,000	SS24	1,830		

TABLE 4-5: SUMMARY OF SURFACE SOIL ANALYTICAL DATA
(All Concentrations in mg/kg)

CADMIUM				NICKEL		SILVER	
Ebasco Study		ISGS Study		Ebasco Study		Ebasco Study	
Sample #	Concentration	Sample #	Concentration	Sample #	Concentration	Sample #	Concentration
Background:	1.0–1.5U		0.04–1.5	Background:	0.070–240	Background:	23–40
SS14	1.0U			SS14	23	SS14	23
SS15	1.2U			SS15	9.5U	SS15	43
SS25	1.4U			SS25	240	SS25	23
SS26	1.4U			SS26	25	SS26	40
SS27	1.0U			SS27	66	SS27	33
SS01	21			SS01	440	SS01	3.2U
SS02	5.0			SS02	180	SS02	3.6U
SS03	1.5U			SS03	190	SS03	31
SS04	8.2			SS04	490	SS04	46
SS05	1.4U	W3	1–10	SS05	34	SS05	81
SS06	1.2U			SS06	9.7U	SS06	150
SS07	1.1U			SS07	240	SS07	24
SS08	3.7			SS08	11	SS08	110
SS09	21			SS09	1,710	SS09	97
SS10	35–67*	C9	>10	SS10	2,010	SS10	94
SS11	1.5U			SS11	600	SS11	38
SS12	33			SS12	750	SS12	54
SS13	1.1U			SS13	120	SS13	64
SS16	1.0U			SS16	250	SS16	91

* Two samples were collected including one duplicate sample. The concentrations were 35 and 67 mg/kg.

TABLE 4–5: SUMMARY OF SURFACE SOIL ANALYTICAL DATA (Cont'd.)
(All Concentrations in mg/kg)

CADMIUM				NICKEL		SILVER	
Ebasco Study		ISGS Study		Ebasco Study		Ebasco Study	
Sample #	Concentration	Sample #	Concentration	Sample #	Concentration	Sample #	Concentration
SS17	15	C7	>10	SS17	740	SS17	42
SS18	48			SS18	490	SS18	15
SS19	27	W18	>10	SS19	450	SS19	210
SS20	1.0U			SS20	780	SS20	50
SS21	27			SS21	1,410	SS21	94
SS22	10			SS22	2,500	SS22	71
SS23	3.7	C5	1–10	SS23	3,460	SS23	72
SS24	1.3U			SS24	600	SS24	41

U – Compound analyzed for but not detected. Value reported is Contract Required Detection Limit (CRDL).

TABLE 4–6: SUMMARY OF ANALYTICAL DATA FOR SURFACE WATER SAMPLES

Analysis	Sampling Locations							
	CRDL	SW01S	SW01D	SW02S	SW03S	SW04S	SW04R	Federal Drinking Water Standards MCL
Inorganic Compounds (mg/l)								
Aluminum	200.0	780	1,000	5,200	5,600	660	200U	--
Cadmium	5	360	370	5.0U	5.0U	5.0U	5.0U	0.005 (Proposed)
Calcium	5,000	100,000	110,000	17,000	5,300	18,000	1,000U	--
Copper	25	90	80	85	90	79	25U	1.3 (Proposed)
Iron	100	1,400	1,400	3,200	3,300	3,200	50U	--
Magnesium	5,000	16,000	16,000	2,400	2,500	4,400	1,000U	--
Manganese	15	1,500	1,600	84	120	930	15U	--
Nickel	40	100	100	40U	40U	40U	40U	0.10 (Tentative)
Silver	10	120	120	17	10U	13	10U	--
Thallium	10	53	47	10U	10U	10U	10U	--
Zinc	20	4,200J	4,100J	500J	1,000J	1,000J	110J	--
Volatile Compounds (µg/l)								
Toluene	1.0	5U	5U	5U	25B	5B	27B	--

CRDL = Contract Required Detection Limits
S = Sample
D = Duplicate
R = Rinsate Sample
J = Estimated Value
U = Compound Analyzed for But Not Detected

TABLE 4–7: SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER SAMPLES

Analysis	Sampling Locations									
	CRDL	MW101S	MW101D	MW101R	MW102S	MW103S	MW01S Total	MW02s Total	RW01S	RW01D
Inorganic Compounds (mg/l)										
Aluminum	200.0	200U	200U	200U	200U	200U	14,000J	13,000J	200U	200U
Cadmium	5	5.0U	5.0U	5.0U	5.0U	5.0U	45	6.0	5U	5U
Calcium	5,000	24,000	24,000	1,000U	240,000J	290,000J	1,100,000	130,000	66,900J	68,800J
Chromium	10	10U	10U	10U	10U	10U	150	69	10U	10U
Copper	25	25U	25U	25U	25U	25U	64	47	35	25U
Iron	100	50U	50U	50U	50U	50U	34,000J	34,000J	2,700J	2,660J
Magnesium	5,000	13,000	13,000	1,000U	170,000	150,000	360,000J	46,000J	8,370	8,400
Manganese	15	15U	15U	15U	15U	380	1,500J	1,400J	160	160
Potassium	5,000	670	670	500U	1,400	3,000	6,500	5,900	1,240	1,230
Silver	10	43	40	10U	420	450	140	11	66	61
Sodium	5,000	240,000	241,000	500U	280,000	95,000	420,000	230,000	12,300	12,400
Thallium	10	10U	10U	10U	180	190	5.0U	5.0U	10U	110
Zinc	20	20U	20U	20U	20U	20U	280	200	88	96
Volatile Compounds (μg/l)										
Toluene	1.0	5U	5U	5U	5U	2J	4J	5U	NR	NR

CRDL = Contract Required Detection Limits
S = Sample
D = Duplicate
R = Rinsate
J = Estimated Value
U = Compound Analyzed for But Not Detected
NR = Analysis Not Run
RW = Residential Well

TABLE 4-8: SUMMARY OF GROUNDWATER QUALITY DATA FOR THE SANDOVAL ZINC SITE

Analyte	Range of Values for Monitoring and Residential Well Water Samples µg/l	Federal Drinking Water Standards As of April, 1990		
		NIPDWR (1) µg/l	MCL (2)/MCLG (3) µg/l	MCLS (4) mg/l
Aluminum	ND (5) – 14,000	--	--	0.05 to 0.2
Cadmium	6–45	10	5 (P)/5 (P)	
Chromium	69–150	50	100 (P)/100 (P)	
Copper	35–64	--	1,300 (P)/1,300 (P)	1
Iron	ND (5) – 34,000	--	--	0.3
Manganese	ND (5) – 1,500	--	--	0.05
Lead	29–34	--	5 (P)/Zero (P)	
Nickel	41	--	100 (T)/100 (T)	
Silver	11–450	50	--	0.09
Toluene	ND (5) – 4	--	2,000 (P)/2,000 (P)	0.04
Zinc	88–280	--	--	5
Calcium	24,000–1,100,000	--	--	
Magnesium	8,370–360,000	--	--	

(1) National Primary Drinking Water Standard
(2) Maximum Contaminant Level
(3) Maximum Contaminant Level Goal
(4) Secondary Maximum Contaminant Levels
(5) None Detected
(P) Proposed Regulatory Value
(T) Tentative Regulatory Value

TABLE 4-9: SUMMARY OF ANALYTICAL RESULTS FROM SEDIMENT SAMPLES

Analysis	Sampling Locations						
	CRDL	SS01S	SS01D	SS02S	SS03S	SS04S	SS04R
Inorganic Compounds (mg/kg)							
Aluminum	200.0	18,000	12,000	9,600	8,560	13,600	200U
Cadmium	5	21	19	5.0	1.5U	8.2	5.0U
Copper	25	820	850	440	330J	1,010J	87
Iron	100	15,000	12,000	13,000	17,100J	66,400J	24,100J
Lead	5	2,200	2,000	490	190J	2,200J	120
Manganese	15	260	1,300	290	270	2,770	170
Nickel	40	440	470	180	190	490	198
Silver	10	3.2U	2.9U	3.6U	31	46	10U
Zinc	20	18,000	15,000	150,000	1,410J	1,080J	16,200

CRDL = Contract Required Detection Limits
S = Sample
D = Duplicate
R = Rinsate
J = Estimated Value
U = Compound Analyzed for But Not Detected

5.0 SUMMARY AND CONCLUSIONS

This section summarizes the major findings of the field investigation. The primary contaminants of concern are associated with the past operation and maintenance of the Sandoval Zinc Company. These contaminants are primarily the heavy metals from the smelting process. A summary of the extent of the inorganic contamination in the soils, groundwater, and waste products is presented.

Analytical results of the tank sample and the duplicate show that the tank contains residual fuel oil with an average heating value of 18,100 BTU/lb. The oil does not contain PCBs but contains 28 mg/kg of lead. Other inorganic analytes detected in low concentrations (less than 50 ppm) were iron, nickel, vanadium, and zinc. Because of the high lead concentration, the oil would be classified as a characteristic hazardous waste (D008).

The ash and waste product inside the buildings contain high concentrations of aluminum, iron, lead, and zinc. Zinc concentrations were typically greater than 200,000 mg/kg. All of the samples collected failed the EP Toxicity test for barium, cadmium, chromium, and lead. However, the waste product and ash on-site are not listed hazardous wastes, but would be classified as characteristic hazardous waste.

The inorganic analytes detected in the surface soil samples include copper, lead, nickel, and zinc. Zinc concentrations ranged from 1,900 mg/kg to 360,000 mg/kg in the samples. Copper, lead, and nickel concentrations typically were much lower, from 10 to 50,000 mg/kg. These concentrations correlate reasonably well with surface soil data from the previous ISWS/ISGS study. Based on the site geology and close correlation of surface concentrations, data on the subsurface soil conditions from the previous study should still be valid and representative of subsurface conditions at the site. This assumption is reasonable in light of the low permeability of the underlying till material. Consequently, the ISWS/ISGS data can be used to approximate volumes of contaminated on-site soils for the feasibility study.

Hydraulic conductivity values obtained from EBASCO's field investigation ranged from 8.8×10^{-4} to 2.8×10^{-3} cm/sec and are within the normal range for silty sand. However, no determination can be made regarding the hydraulic gradient or the groundwater velocity.

No PCBs were found in the groundwater samples, but they do contain high concentrations of cadmium, chromium, copper, and silver. These contaminants could have been transported from the impacted surface soil to the groundwater via abandoned investigative wells which have not been plugged and/or damaged and improperly installed wells that still exist on-site. The groundwater samples collected from MW01 and MW02, the newly installed wells, both exceed the National Interim Primary Drinking Water Regulations (NIPDWR). The residential well sample contained levels of silver and thallium exceeding the NIPDWR standards.

There is considerable difference in the water quality data between the two newly installed wells and the three old monitoring wells. Additional sampling would be required to resolve this discrepancy and establish whether or not samples from the new wells are representative of current site conditions. Filtered samples show concentrations of dissolved metals and are more important from the stand point of compliance with drinking water standards, unfiltered samples represent a worst case scenario for determining treatment options.

Additional monitoring wells will probably not be necessary to characterize the groundwater quality on-site. A conventional pump and treat system is not likely to be considered a favorable alternative to remediate the groundwater at this facility because of the low productivity of the Hagarstown formation. There is no immediate health concerns for the drinking water at Sandoval because the city receives drinking water from Centralia. The current groundwater quality on-site poses no threat to the deep productive water bearing aquifer in the Hagarstown formation so long as the soil has adequate ion-exchange capacity and the contaminant metals are retained in the soil. However, the potential for groundwater transport of metals can be substantially reduced or eliminated by removing the metals from the soil or immobilizing them in the soil.

Based on one round of sampling, the concentrations of cadmium, copper, nickel, and silver in the surface water from the farm pond exceed the MCLs for drinking water. This water would require treatment prior to discharge.

Sediments in the vicinity of the farm pond also contain high concentrations of metals. The farm pond has not been previously investigated, and additional sampling to further define the extent of contamination for remediation would be required as part of the remedial design for this site.

The high levels of lead and zinc in the sediments suggest that these metals were probably not transported to the farm pond area through surface water runoff or groundwater movement. The terrain on-site is essentially flat and is not conducive to such transport. The high metals concentration in the sediments could have resulted from using the farm pond as a processing unit to store waste water when the smelters were in operation. These sediments would likely be classified as characteristic hazardous waste.

6.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This FS was performed according to the following steps:

- Establish potential remedial objectives.
- Identify general response actions to meet remedial objectives, including no action.
- Identify remedial technologies under each general response action with emphasis on permanent solutions.
- Screen remedial technologies based on technical considerations and then, use those technologies to develop remedial alternatives.
- Screen remedial alternatives according to effectiveness, implementability, and cost.
- Perform a detailed evaluation of the remaining remedial alternatives based on short-term effectiveness; long-term effectiveness and permanence; reduction of toxicity, mobility, and volume; implementability; cost; compliance with ARARs; overall protection of human health and the environment; and state and community acceptance, and
- Perform a comparative evaluation between remedial alternatives.

The FS methodology for each of these steps is described in detail in the appropriate sections.

This section summarizes the screening process used to identify technologies appropriate to remedy contaminants of concern at the Sandoval Zinc site.

6.1 Remedial Action Objectives

The IEPA established Remedial Action Objectives (RAOs) based on the results of the additional field investigation, the ISWS/ISGS study, and the concentration of contaminants considered to be acceptable for the site. These objectives are listed in Table 6-1 by parameter separately for groundwater and soil.

The IEPA's current remediation strategy is to identify and evaluate those remedial technologies and process options that can achieve the established RAOs. These are numerical objectives, which if attained, would allow the site to be restored for unrestricted use. These objectives do not take into consideration contaminant pathways, potential receptors and the potential carcinogenic and non-carcinogenic risk posed by the contaminants to those receptors.

For the purpose of this FS, EBASCO has assumed that prevention of exposure to the contaminants is also a remedial action objective. This will facilitate evaluation of those remedial technologies that cannot achieve the numerical objectives, but can be effective in eliminating the risk of exposure to contaminants.

6.2 The Study Area for the Feasibility Study

The study area for this Feasibility Study is shown in Figure 6-1. After EBASCO completed the additional field investigation in 1990, the IEPA installed a fence around the site to restrict public access as part of the initial step to prevent exposure to contaminants on-site. This fence line essentially outlines the boundary established by the IEPA for the purpose of this Feasibility Study. However, also included within this boundary is the "farm pond" located east of the site. Any area outside the designated boundary is beyond the scope of this Feasibility Study.

6.3 Impacted Areas for the FS

This section summarizes the five areas of concern that are addressed in this FS. These areas are: 1) the above ground storage tank, 2) waste product/ash and miscellaneous debris, 3) impacted soil, 4) impacted groundwater, and 5) the farm pond and associated impacted sediment.

6.3.1 Aboveground Storage Tank

The aboveground storage tank (AST) located on-site was found to contained residual fuel oil. A sample of the fuel oil was collected for laboratory analysis (see Section 4.0) and was determined to have sufficient heating value to be used as supplementary fuel for combustion. However, in September 1991, a valve in the outlet line failed and released a considerable portion of the tank contents onto the ground. The IEPA implemented emergency response action to mitigate the immediate hazards posed by the spill. As a result of the emergency response action all of the visibly impacted soils have been removed and are presently stored on a plastic liner inside one of the on-site buildings. The volume of impacted soil removed was approximately 500 $yd.^3$. Both the impacted soil and the aboveground storage tank, which is presently empty, will require proper disposal.

6.3.2 Waste Product/Ash and Miscellaneous Debris

Approximately 5,000 lbs. of waste product/ash is present inside the on-site buildings. Based on the EP Toxicity Test results (see Section 4.0) this material is considered a characteristic hazardous waste. The miscellaneous debris on-site consist of building rubble, remains from the old smelter, and other general debris inside the buildings. The volume of the miscellaneous debris is estimated to be 1,500 $yd.^3$.

6.3.3 Impacted Soil

Field investigation results indicate that both the surface and the sub-surface soil are impacted with heavy metals. Based on the IEPA established clean up objectives presented in Table 6-1, more than 425,000 cubic yards of impacted soil requires remediation. An estimate of the volume of soil to be remediated is shown in Table 6-2. The calculations for the soil volume estimate are provided in Appendix D.

In estimating the volume of soil to be remediated, the required dimensions were taken from the surveyed map prepared as part of EBASCO's Additional Field Investigation, the report on the previous study conducted by ISWS/ISGS, and the sketch provided by the IEPA to delineate the site boundary for this FS. Based on the available information regarding metal concentrations in the soil, the site area to be remediated for each metal is estimated to be 510,000 ft^2 (1200 ft x 45 ft). The depth to which remediation would be required depends upon the specific metal and its concentration in the soil. For example, the cadmium concentration is greater than 1 mg/kg at depths up to 17.5 ft below the surface, whereas lead concentration is greater than 100 mg/kg at the same depth. The depth to specific concentrations were taken from the concentration profile charts presented in the ISWS/ISAS report. Sample calculations for estimated volumes of impacted soil are presented in Appendix D.

In the ISWS/ISGS study, sub-surface soil samples were collected up to a depth of approximately 28 feet. The concentrations listed in Table 6-2 are the lowest concentrations for which sub-surface analytical data is currently available. These data cannot be reliably extrapolated to determine the depths at which the IEPA established RAOs can be achieved because the concentration profile charts in the ISWS/ISAS report do not indicate any specific correlation between depth and soil concentration. Consequently, the table represents the minimum volume of soil requiring remediation to achieve the concentrations listed.

6.3.4 Impacted Groundwater

To estimate the volume of groundwater requiring remediation, the groundwater in contact with the soil was assumed to cover an area equivalent to that covered by the soil (i.e., 510,000 ft^2). Since contaminants were found at depths up to 28 feet, a total depth of 30 feet was assumed as the depth up to which groundwater in contact with the soil is expected to be impacted. Since the average depth to groundwater on-site is approximately 5 feet, the estimated thickness of the impacted water is 25 feet. The total volume occupied by impacted soil and associated groundwater would thus be a cube with dimensions of 1200 ft x 425 ft x 25 ft. Since the groundwater exists in the interconnected pores of the soil, only a portion of this cube volume can be attributed to the groundwater. A porosity of 15% was assumed for this calculation. In addition to this, some groundwater also exists as moisture in the soil above the water table. This is estimated to be 10% of the volume occupied by the soil.

Thus, the estimated volume of impacted groundwater beneath the site to be remediated is 15.7×10^6 gallons. Appendix D presents sample calculations to show how this volume was calculated.

6.3.5 Farm Pond and Associated Sediment

Field investigation results (Section 4.0) indicate that the both the surface water and sediments of the "farm pond" contain elevated levels of heavy metals. These metals include aluminum, cadmium, copper, iron, lead, nickel, silver and zinc. EP Toxicity test were not conducted on the sediment samples collected, however, aluminum, iron and zinc were all detected at concentrations greater than 10,000 mg/kg. Lead was also detected at concentrations of greater than 2,000 mg/kg. Therefore, it is likely that the sediments will possess hazardous waste characteristics.

To estimate the volume of impacted sediments requiring remediation, it was assumed that the metals were present in the top one foot of sediment. The "farm pond" is approximately one acre in size, therefore, an estimated 43,500 ft^3 (1,600 yd^3) of impacted sediment is present on the bottom of the pond.

6.4 General Response Actions

This section presents general response actions identified to meet the RAOs established for the Sandoval Zinc site. Table 6-3 summarizes the general response actions which were determined to be feasible for the site.

These general response actions (GRAs) were selected from a comprehensive list of general response actions typically considered for the clean-up of hazardous waste sites. The selections were based on information obtained from the Additional Field Investigation, the ISWS/ISGS study (1982), and site specific conditions. The GRAs were developed from the October, 1988 Interim Final RI/FS Guidance Document (USEPA, 1988), The Superfund Innovative Technology Evaluation Program: Technology Profiles (USEPA, 1990), information obtained from the Alternative Treatment Technology Information Center (ATTIC), experience on other hazardous waste projects, knowledge of new technologies, and the professional judgment of the engineers performing the Feasibility Study. For example, remedial technologies designed to remove or destroy organic contaminants were not considered since heavy metals are the primary contaminants of concern at the site.

6.5 Identification and Screening of Technology

The next step in the screening process is to identify the remedial technologies associated with each general response action applicable to the Sandoval Zinc site and then to determine their feasibility. Each applicable general response action contains many remedial technologies, and an exhaustive list could be developed from various USEPA guidance documents and handbooks, as well as from other feasibility studies. However, some of these technologies are obviously not applicable to this site. Therefore, this identification and screening process concentrates on just those technologies that are potentially applicable based upon the established criteria which includes remedial objectives, site specific conditions and the characteristics of the contaminants of concern. This section introduces and discusses the technologies in each general response action and presents the results of the screening process. Remedial technologies are discussed in the order in which they are listed in Table 6-3.

6.5.1 No Action

The No Action response for the Sandoval Zinc site means that no remediation of impacted material, soil, groundwater or sediment will be designed or implemented. Under a No Action scenario, contaminants may leach from the soil and migrate to the groundwater. Contaminants may also migrate off-site through wind dispersion and surface water run off.

Although the No Action alternative does not remove or treat the sources of contamination, this general response action is required by the National Contingency Plan (NCP) and is retained to provide for a comparison of public health and environmental impacts later in the evaluation process.

6.5.2 Institutional Controls

Institutional Controls (ICs) represent minimal actions necessary to reduce the potential for exposure to the contaminants on-site. Two forms of ICs commonly used include: (1) Groundwater Monitoring and (2) Access restrictions.

Groundwater monitoring involves sampling and laboratory analysis of groundwater samples collected from existing monitoring wells. Monitoring can be implemented to determine whether the groundwater quality is deteriorating through contaminant migration.

Access restrictions are intended to reduce public access to the site and thus reduce the opportunity for exposure to contaminants. The IEPA has already implemented one form of access restrictions by installing a fence around the site and posting warning signs to restrict physical access to the site. Another form of restriction that could be imposed is deed restrictions. Deed restrictions may be used to restrict activities such as installation of drinking water wells, property resale and property use.

ICs can be considered as a part of most remedial alternatives, and are therefore retained for further evaluation.

6.5.3 Containment

There are two containment technologies applicable to the Sandoval Zinc site: (1) Barrier Walls to contain movement of impacted groundwater and (2) capping to isolate impacted soils.

6.5.3.1 Groundwater Containment Vertical Barriers

Impermeable barriers can be used to divert groundwater flow around the site or to contain impacted groundwater from migrating off-site. Various methods and materials considered for use in constructing groundwater barriers include the following:

- Slurry walls
- Grout curtains

- Sheet pilings

Slurry Walls

Slurry walls are the most common subsurface barriers utilized because they are a relatively effective method of reducing groundwater flow in unconsolidated soils. The slurry wall is constructed in a vertical trench that is excavated under a slurry. This slurry, which is usually a mixture of bentonite and water, acts essentially like a drilling fluid in that it hydraulically shores the trench wall to prevent high fluid losses into the surrounding soil. Slurry wall types are differentiated by the material used to backfill the slurry trench. Two of the most commonly used methods are: (1) soil-bentonite, and (2) cement-bentonite.

Soil-bentonite slurry walls are the most commonly used subsurface barriers. They can be installed either upgradient of the site to divert groundwater flow, downgradient to partially contain contaminant plumes or around the circumference of the site for containment. Soil-bentonite slurry walls are constructed by backfilling a vertical trench with a mixture of soil, bentonite and water. In the vertical perspective, the slurry wall may be either "keyed-in" or hanging. Keyed-in slurry walls are constructed in a trench which has been excavated into a low-permeability confining layer such as a clay deposit or bedrock. This layer will form the bottom of the contained site and a good key-in is essential to adequate containment. Hanging slurry walls, however, are not tied into a confining layer but extend several feet into the water table to act as a barrier to floating contaminants (such as oils and fuels) or migrating gases. The use of hanging slurry walls in site remediation is therefore, relatively rare and most installations utilize keyed-in slurry walls.

Soil-bentonite slurry walls have the lowest overall cost, the widest range of chemical compatibilities and the lowest permeabilities if properly constructed. At the same time, soil-bentonite walls have the highest compressibility (least strength), require a large work area, and because the slurry and backfill are fluid, they are only applicable to sites that can be graded to nearly level.

Cement-bentonite slurry walls share many of the same characteristics with soil-bentonite slurry walls. The principal exception is that the excavated trench is filled with a slurry composed primarily of portland cement and bentonite. Only a small percentage of the natural soils are also used in this mixture. The cement-bentonite slurry is allowed to set, forming a low permeability containment barrier. Generally less area is required for construction when compared to soil-bentonite slurry walls, however, excavated soils from the trench must be disposed of properly.

Slurry wall construction requires a large work area which may not be available at the Sandoval Zinc site. In addition, they are not effective unless keyed into a continuous confining unit. The lithology at the Sandoval Zinc site does not provide these conditions. Therefore, this technology is not retained for further evaluation.

Grout Curtains

Grout curtains are subsurface barriers that are constructed by injecting grouting material, under pressure, into the ground around the area to be contained. The grouting material can consist of cement, cement-bentonite slurry, alkali silicates, or organic polymers. The design of a grout curtain depends on soil characteristics and the capatability of the grout with the contaminant(s) to be contained.

Grout curtains are rarely applied to contaminated sites for many reasons. A major concern is that inadequate grout penetration could create gaps or discontinuities in the curtain. Grout curtains also require more monitoring than any other type of subsurface barrier and they may not be always capable of attaining very low permeabilities. Therefore, this technology is not retained for further consideration.

Sheet Piling

Sheet pilings are vertical metal or wood sheets driven into the ground to create a subsurface wall. They are usually installed to keep water out of a given construction area. The sheet piles are constructed by interlocking the sheet edges and driving them into the earth a short distance at a time until the desired depth is attained over the entire length of the wall. Sheet piling is used for temporary dewatering of an area, as well as for erosion protection, where the wall system would be subject to flowing surface water or wave action. The major parameters to be considered in the design of sheet piling are material permeability and the wall dimensions.

Two of the largest drawbacks of sheet piling are corrosion and the deflection of the piles by rocks or buried debris. This damage would likely render the wall ineffective and it is very difficult to inspect the completed structure for such damage. Therefore, due to the unpredictability of the integrity of the wall as well as the unfavorable lithology of the site, this technology is not retained for further evaluation as a groundwater barrier.

6.5.3.2 Capping

Capping technologies are used primarily to minimize the potential for direct contact with contaminants and reduce off-site transport of exposed contaminants and waste materials.

Caps containing impermeable barriers also minimize the percolation or infiltration of precipitation/surface waters. Capping can involve the installation of a compacted soil zone over the waste and can include an overlying layer of topsoil and vegetation cover. Excavation and/or regrading of some of the material in preparation for capping is also usually required.

The selection of capping materials and cap design is influenced by the remedial objectives as well as specific factors such as local availability and cost of cover materials, properties of cover materials, the nature of the contaminants being covered, local climate and hydrogeology, and the projected future use of the site in question. For the Sandoval Zinc site, three capping methods were considered: (1) a non-RCRA cap, (2) a RCRA cap, and (3) vegetation.

Non-RCRA Cap

A non-RCRA cap contains just a single layer of low permeability material, and may be acceptable if there is reasonable assurance that the integrity of such a cap will be continually maintained. A drainage layer is usually not provided over the impermeable layer, so grading must be provided to convey water away from the cap. However, since the cap is made of material which is not impermeable surface water will still pass through. None the less, a non-RCRA cap will reduce, the risk of exposure through inhalation and ingestion of contaminants in the soil. Therefore, the non-RCRA cap is retained for further evaluation.

RCRA Cap

A RCRA cap generally contains two layers of impermeable materials to provide assurance of a long service life, and generally consists of an overlying drainage layer and an underlying foundation layer. The low permeability layer may consist of some combination of clay, cement, concrete, asphalt, or synthetic membranes. The drainage layer is designed to convey water away from the layer of low permeability thereby limiting the hydraulic head on the material and the potential for infiltration. Drainage and foundation layers are usually constructed of sand, crushed stone or geotextile drainage fabrics.

RCRA caps are normally used to cover highly contaminated areas in order to prevent infiltration and exposure to contaminants. This level of protection may be necessary to prevent the risk of exposure through inhalation, ingestion and direct contact. Therefore, this option is retained for further evaluation.

Vegetation

Vegetation is a special class of cap. Unlike a non-RCRA cap, no low permeability material (e.g., clay) is placed on top of the impacted soil. On the other hand, top soil is placed as a cover over impacted surface soil. A geotextile fabric may be installed to separate the clean topsoil cover and the impacted soil. The fabric may also provide an additional barrier through its resistance to excavation by small tools. Vegetation is induced by seeding the top soil with appropriate plant species. Deep rooted vegetation, which may threaten capping systems, should be avoided. Vegetation is aesthetically appealing and protects the soil cover from erosion. Vegetation is retained for further evaluation.

6.5.4 Pump-and-Treat

Groundwater pump-and-treat systems involve the extraction of impacted groundwater and treating the recovered groundwater above ground to remove the contaminants of concern. This technology involves the installation of extraction wells or collection trenches and submersible pumps to extract the groundwater for treatment.

The feasibility of treating impacted groundwater is dependent on the contaminants present, their concentrations, the physical/chemical properties of the contaminants in the groundwater, and the properties of water bearing unit.

Once the groundwater has been extracted there are several technologies available which can be utilized to treat the water. These treatment systems include both physical and chemical treatment. Physical treatment systems which were considered include filtration, reverse osmosis and ion exchange. The only chemical treatment technology evaluated was chemical precipitation.

6.5.4.1 Physical Treatment

Physical treatment removes contaminants from the groundwater through processes that involve only a physical change. Dissolved metal salts are the contaminants of concern in the groundwater at the Sandoval site. However, the dissolved metals can be adsorbed by suspended solids. These dissolved and suspended solid contaminants can be separated from groundwater to a different medium. The commonly used technologies to affect this transfer are filtration, reverse osmosis and ion-exchange.

Filtration

Filtration is a process of separating and removing suspended solids from a liquid by passing the liquid through a porous medium. The porous medium may be fibrous fabric (paper or cloth), a screen or a bed of granular material such as sand. Suspended solids are not of primary concern at the Sandoval Zinc Site. However, the dissolved metal salts can become associated with the suspended solids and pretreatment by filtration is appropriate to prevent plugging or overloading of downstream process equipment used for the removal of the metal salts. Filtration is effective for removing suspended solids before treatment or removing flocculants after metals precipitation, and is retained for further evaluation.

Reverse Osmosis

Osmosis is when a semi-permeable membrane separates two solutions of different dissolved solids concentrations, pure water will flow through the membrane into the concentrated solution, while ions (e.g. dissolved salts) are retained behind the membrane. During reverse osmosis (RO), pressure is applied to the more concentrated solution to reverse the normal osmotic flow, and pure water is forced through the semi-permeable membrane into the less concentrated solution. The three most commonly used RO membrane materials are cellulose acetate, aromatic polyamides, and thin-film composites (consisting of a thin film of a salt-rejecting membrane on the surface of a porous support polymer). The membrane utilized for any particular system is dependent on temperature, pH and other limitations of the membrane material.

RO is primarily used to separate water from a feed stream containing inorganic ions. The purity of the recovered water is relatively high, and the water is generally suitable for recycling. The maximum achievable concentration of salt in the reject stream is usually 100,000 ml/L because of osmotic-pressure considerations.

One of the major applications of RO has been in the electroplating industry. The separation process does not require a energy intensive phase change and a result operating costs associated with energy consumption are relatively low. Capital costs are also relatively low and a low degree of operational skill is required. Therefore, this remedial technology has been retained for further evaluation.

Ion Exchange

Ion exchange is a separation process in which selected pollutant ions in a wastewater are removed by the ion exchange material (resin), while non-pollutant ions are exchanged from the resin into the wastewater. In practice, ion exchange "beads" are placed in a column and water to be treated is passed through the bed. Most ion exchange resins are high-molecular-weight organic polymers onto which chemical functional groups (e.g., sulfonic, carboxylic, phenolic, amines) are added.

The degree of the reaction (exchange) will depend on the resin's selectivity and as a separation technology, ion exchange does not eliminate the ionic contaminants but concentrates them. The saturated resin must be replaced or regenerated after each loading cycle.

Ion exchange has been used for the purification of public water supplies and demineralization (softening of water in process industries, particularly in metal plating and electronics manufacturing. Ion exchange systems are available and can be easily fabricated for specific applications and thus have been retained for further evaluation.

6.5.4.2 Chemical Treatment

Chemical treatment involves removing contaminants from the groundwater through chemical change. The most commonly available technology applicable for chemical treatment of groundwater impacted with heavy metals like at the Sandoval Zinc site is chemical precipitation.

Chemical Precipitation

Precipitation is a process by which the chemical equilibrium of a waste stream is altered to reduce the solubility of heavy metals. The metals precipitate out as a solid phase and are taken out of the solution by solids removal processes. Metals precipitation is not one unit operation but a combination of coagulation, flocculation, sedimentation, and filtration processes.

The solubility of most heavy metals is reduced by raising the pH of a wastewater from 8 to 12. Although removal of metals as sulfides or carbonates is effective, hydroxide precipitation is, by far, the most common precipitation process. In hydroxide precipitation, hydrated lime (i.e., calcium hydroxide) or caustic (i.e., sodium hydroxide) is added for pH adjustment. Both alkalies have advantages and disadvantages. The cost of lime is less than that of caustic; however, the feed equipment is more expensive. Lime also produces a drier cake than caustic but sludge production is greater.

Adjustment of pH alone, however, is usually insufficient for removal of the insoluble metal hydroxide solids. Coagulants, such as iron salts, alum, and polymers, must be added to neutralize charges and to cause the formation of metal precipitates. Chemical coagulants are added in a rapid mix tank and are followed by gentle mixing or "flocculation," which causes interparticle bridging and formation of flocs which settle rapidly. The settled solids can then be removed by a clarifier, a filter, or both.

Metal hydroxide precipitation is an established wastewater treatment process for the electroplating and metal finishing industries. Therefore, this technology was retained for further evaluation.

6.5.5 Soil Treatment

Soil treatment technologies applicable to the Sandoval Zinc site are divided into two categories: (1) physical/chemical treatment technologies and (2) solidification/ stabilization technologies.

6.5.5.1 Physical/Chemical Treatment

Physical treatment consists of transferring the contaminants in the soil to another media. Chemical treatment removes the contaminant through chemical reaction. A brief discussion of applicable technologies follows.

Chemical Extraction

This process involves mixing the impacted soil with a concentrated acid or chelating solution. The acid solution extracts the metals from the soil which is then thoroughly washed and returned to its original location. However, a large portion of the impacted soil at the site consists of slag from the smelting process. The slag contains high levels of heavy metals and is not easily reduced in size to expose the metals for extraction. Therefore, chemical extraction is not retained for further consideration.

Electro-Reclamation

Electro-reclamation removes heavy metals and other contaminants from soil and groundwater based on the phenomena of electro-osmosis, electrophoresis and electrolysis. These phenomena occur when the soil is electrically charged with direct current (DC) by means of one or several electrode arrays. Metal contaminants migrate to the negatively charged electrodes and are captured in the chemical solution circulating in the electrode. The solution is then treated in a water treatment facility.

Electro-reclamation can be applied both in-situ and on excavated soil. Bench scale experiments on fine sand (Geokinetics, 1989) have shown that cadmium concentrations can be reduced from 319 mg/kg to less than 1 mg/kg (> 99% removal). Lead concentrations were reduced from 638 to 238 mg/kg (65% removal). Other soil types were also tested, but had lower removal efficiencies. Field experiments were conducted on a sediment layer (70 m long x 3 m wide x 20-50 cm deep) impacted with lead and copper. Lead removal efficiencies varied from 50-94 percent with an average of 74 percent. Other field experiments have also been conducted to evaluate removal of metals such as zinc, cadmium, and arsenic with varying degrees of success.

The subsurface soils at the Sandoval site consist of silt clays which do not have a high hydraulic conductivity. As a result, recover efficiencies are not expected to be high and this remedial technology was not retained for further evaluation.

Soil Washing

The soil washing process extracts contaminants from soil using water or an aqueous solution composed of chelating agents, surfactants, acids, or bases. The primary function of soil washing is a physical volumetric reduction of fine silt, clay, and colloidal fractions from cleanable coarse sand and gravel components, since the fine silts and clay typically absorb organic contaminants.

This technology has been demonstrated to remove halogenated and nonhalogenated hydrocarbons and heavy metals such as lead, cadmium, chromium copper, and nickel. This technology is most effective for soil with a high proportion of sand having a majority of soil particles greater than 200 mesh, or 0.074 mm (USEPA, 1988b). The subsurface soils at the Sandoval site consist primarily of slag. As a result the metals associated with the impacted soil have not been adsorbed but are inherent to the soil. Therefore, although soil washing will remove some of the metals in the soil it will not effectively remediate the soil. This technology was therefore not retained for further evaluation.

6.5.5.2 Solidification/Stabilization

Two types of solidification/stabilization technologies are applicable to the Sandoval Zinc site: (1) On-site stabilization and (2) In-situ stabilization.

On-Site Stabilization/Solidification

On-site stabilization methods are designed to immobilize contaminants, minimize leaching potential reduce toxicity of the waste, and improve the waste handling characteristics. Impacted material is excavated and mixed with treatment reagents that combine physically and/or chemically with impacted materials to decrease the mobility of the waste constituents. The end product may be a standing monolithic solid or may have a crumbly, soil-like consistency, depending upon the amount and type of reagent added. After the contaminant is immobilized, the material can be consolidated to a common area of the site and placed in on-site containment or an engineered landfill.

On-site stabilization has demonstrated full-scale success as a remediation technology for the treatment of wastes such as the soils and sediment at the Sandoval Zinc site which contain heavy metals. This technology, however, will increase the volume of soil or sediment substantially and is therefore, only retained for further consideration to remediate the impacted sediments of the farm pond.

In-Situ Stabilization/Solidification

As with on-site stabilization, in-situ stabilization methods are designed to immobilize contaminants, minimize leaching potential, and reduce toxicity of the waste. With in-situ stabilization, impacted soil is left in-place and mixed with treatment reagents to decrease the mobility of the waste constituents. Stabilization continues throughout the impacted area until all contaminants of concern are immobilized.

In-situ stabilization can effectively immobilize wastes containing heavy metals, PCBs, and PAHs with high molecular weight. The amount and type of reagent used is determined by the contaminants of concern, their respective concentrations, and the soil type. The use of in-situ stabilization would require several formulation of reagent. However, greater process control is afforded by excavating the material.

Soil mixing is divided into two categories, Shallow Soil Mixing (SSM) and Deep Soil Mixing (DSM). The SSM system uses a crane mounted mixing system. The mixing auger, three feet to 12 feet (1.0 meter to 3.7 meters) in diameter, is driven by a high torque turntable. The mixing head can be enclosed in a bottom-opened cylinder to allow for closed system mixing of the waste and treatment chemicals.

Treatment chemicals are transferred pneumatically for dry chemicals or pumped in cases where fluid chemicals would be used. Treatment chemicals are precisely weighed (for dry systems), or volumetrically measured (for fluid systems), to allow the correct proportions to be mixed with the untreated waste sludge or soil. The bottom-opened cylinder is lowered into the waste and the mixing blades are started while chemicals are introduced. The blades mix through the total depth of the waste in an up-and-down motion. A negative pressure is kept on the head space of the bottom-opened cylinder to pull any vapors or dust to the vapor treatment system. Once a cylinder of waste is mixed, the blades are retracted inside the bottom-opened cylinder and the cylinder is removed. The cylinder is then placed adjacent, and overlapping, to the previous cylinder and the process is repeated until all waste has been treated.

In-situ stabilization is potentially applicable to the Sandoval Zinc site, and is retained for further consideration.

6.5.5.3 Metals Recovery

Metals recovery from soil appears to be feasible because high levels of zinc (10,000 - 100,000 mg/kg), lead (1,000 - 10,000 mg/kg) and copper (> 1,000 mg/kg) exist in the subsurface soils. Metals can be recovered by using thermal processes or by heap leaching.

Thermal Processes

Thermal processes involve concentrating the metals concentration in the soil by physical/chemical treatment-processes (e.g., air floatation, chemical extraction, chemical oxidation) and then recovering the metals in high temperature furnaces. Recovery of metals from smelter residues is a common practice in the mining industry. Therefore, thermal processes are retained for further evaluation.

Heap Leaching

Heap leaching is a commonly used technique in the mining industry to recover valuable metals from slag or tailings generated from primary processing of ores. The technique consists of constructing a heap of the material and leaching the heap with a suitable reagent. The heap is constructed on an impervious pad with a system for collecting the leachate, which is then recycled. The commonly used reagents which may be appropriate for removing zinc and copper from the tailings/slag are sulfuric acid, potassium cyanide, and nascent chlorine solution.

Heap leaching has the following advantages:

- The technique is demonstrated and proven effective for recovering valuable metals like gold and silver.
- The system is simple to construct and install.
- The cost of processing is typically low compared to other above ground thermal recovery processes.

Although the characteristics of the soil are likely to be different from slag or tailings, heap leaching is potentially applicable and retained for further evaluation.

6.5.6 Excavation and Removal

Removal technologies refer to methods used to excavate and handle soils, sediments, wastes and solid materials. Excavation technologies provide no treatment of the wastes, but may be used prior to treatment or disposal technologies to facilitate removal of wastes from designated areas. Dewatering and supernant treatment may also be conducted in conjunction with removal technologies.

6.5.6.1 Soil Removal

Excavation of contaminated soils or subsurface wastes may be performed by a variety of technologies. Typical equipment includes draglines, loaders, dozers, pans (scrapers), backhoes and trucks. Excavated material can be loaded onto trucks, and hauled off-site to an approved treatment and disposal facility or it can be treated and disposed of on-site.

This technology was therefore retained for removal of soil and sediment.

6.5.7 Disposal

Disposal options available for the Sandoval Zinc site vary according to the media. Options for each of the media present at the site are discussed in the following paragraphs.

6.5.7.1 Groundwater Discharge

Three process options are considered for groundwater discharge: (1) off-site discharge to a Publicly Owned Treatment Work (POTW) for treatment, (2) recharge after treatment and (3) discharge after treatment to surface water body.

Off-Site Discharge

Off-site disposal involves extracting the impacted groundwater and transporting it off-site to a POTW for treatment. The City of Centralia, which supplies water for Sandoval, has a wastewater treatment plant. This plant is located close to the Sandoval Zinc site. However, since the sludge generated by the POTW is used for land applications, the POTW is not permitted to accept groundwater impacted with metals. Therefore, this option is not retained for further evaluation.

Recharge to Groundwater

Subsurface distribution systems, such as french drains, infiltration galleries or injection wells, are means of returning the treated groundwater at shallow depths. If the water is discharged within the site boundaries it could flush out more contaminants, thereby increasing treatment requirements, or dilute the existing impacted water, thereby reducing the efficiency of the treatment system. Therefore, this option is eliminated from further consideration.

Discharge to Surface Water Body

If the treated groundwater complies with Illinois State water quality standards, it could be discharged to the off-site drainage ditch. Therefore, this discharge option is retained for further evaluation.

6.5.7.2 Sludge Disposal

Groundwater treatment will generate sludge containing the metals removed from impacted groundwater. The quantity of sludge generated is expected to be small and can be discharged off-site to a permitted RCRA facility. This option is retained for further consideration.

6.5.7.3 Excavation and Land Disposal

Excavation and land disposal is an established and commonly used technology for impacted soils. Two types of available disposal options are: (1) off-site secure landfill and (2) on-site secure landfill.

Off-Site Secure Landfill

In this option, impacted soil would be excavated and transported to an off-site RCRA disposal facility. This option is retained for further evaluation.

On-Site Secure Landfill

In this option, a secure landfill is constructed on-site for the disposal of impacted soil. This option is impractical because the site does not have sufficient area to construct a secure landfill. In addition, the shallow depths to groundwater (average 5 ft.) on-site further limits the area available for disposal. Therefore, on-site landfill disposal is not retained for further consideration.

6.5.8 Collection

Collection technologies are an integral part of any groundwater treatment system. Numerous structures or mechanical systems can be used to collect and transfer impacted groundwater for treatment.

6.5.8.1 Subsurface Drainage Systems

Although many different types of subsurface drainage systems are commonly used, only one system is described due to its applicability based on the limited area and site specific conditions.

French Drain/Interceptor

French drains and interceptor trenches are two subsurface drainage systems that can be used to collect or intercept and convey groundwater by gravity flow. They can serve the same general purpose as a groundwater pumping system as they create a continuous zone of influence in which groundwater flows toward the drains.

The drains are typically placed perpendicular to the direction of the groundwater flow to intercept the contaminant plume or prevent groundwater movement into a impacted area. The drains are constructed by excavating a trench, lining the trench with filter fabric, placing a gravel bed with perforated drain pipe, and backfilling the trench with gravel. Intercepted groundwater flows along the trench or french drain to a collection point or sump for discharge and/or treatment and discharge.

Construction of a french drain or interceptor trench would involve the excavation and disposal of potentially impacted soils. The presence of a shallow water table and fine sands would require that excavation be sheeted and braced to limit excavation quantities and assure stability of existing structures. This process option is retained for further evaluation.

6.5.8.2 Diversion

Diversion involves regrading the site to reduce surface water infiltration and control erosion. Grading is often performed as part of surface scaling activities. Grading is therefore retained for further evaluation.

6.6 Disposal of Waste Product/Ash and Debris

Off-site disposal to a secure RCRA landfill is a viable technology for disposing the waste product/ash and debris stored on-site. This technology is retained for further evaluation.

6.7 Disposal of Above Ground Storage Tank

The above ground storage tank which contained fuel oil requires proper closure. This action consists of decontaminating the tank and associated piping, properly disposing of rinse waters generated during the decontamination, and appropriately disposing of the tank off-site. Two options are available for disposal: (1) the tank can be removed and disposed off-site and (2) the tank can be abandoned in place. Both are potentially applicable to the site. Disposal is retained for further evaluation.

6.8 Summary of Initial Screening

Figure 6-2 summarizes the initial screening of technologies applicable to the Sandoval Zinc site. Technologies which are eliminated from further consideration are shaded.

STATE OF ILLINOIS
ENVIRONMENTAL PROTECTION AGENCY

SITE SKETCH

Date of Inspection: August 29, 1991 Inspector: Bruce Ford

Site Code: L1210500002 County: Marion

Site Name: Sandoval Zinc Time: 1:00 pm – 2:25 pm

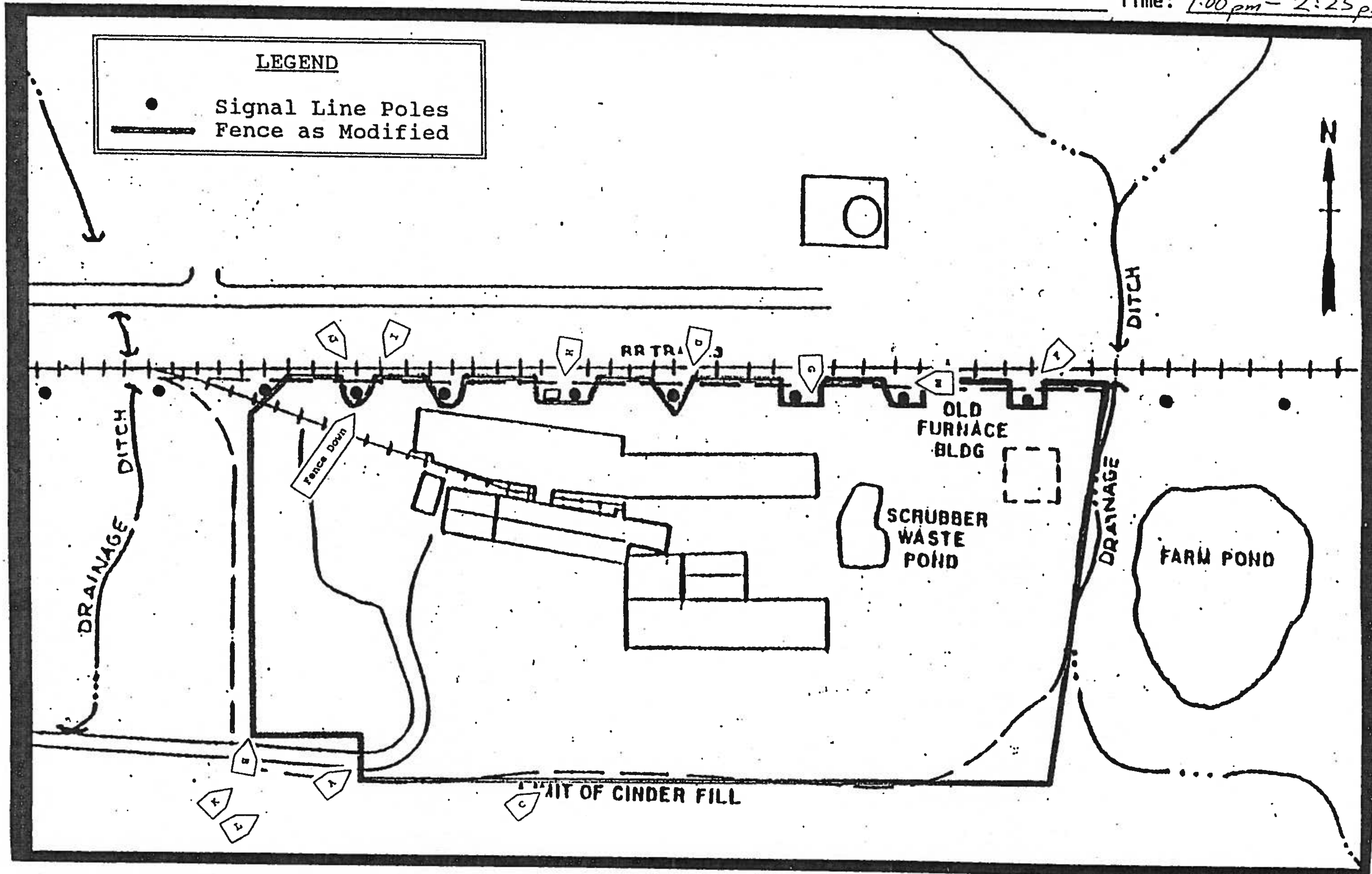


Figure 6-1: Study Area For The Feasibility Study

FIGURE 6-2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR SANDOVAL ZINC SITE, ILLINOIS

Response Actions	Remedial Technologies	Process Options	Descriptions	Screening Comments
No Action	None	Not Applicable	None	Required for consideration by the National Contingency Plan.
			Groundwater/Surface Water	
Institutional Controls	Monitoring	Groundwater Monitoring	Perform water quality analyses to monitor contaminant migration and assess future environmental impact.	Potentially applicable.
	Groundwater Restrictions	Deed Restrictions	Institute deed restrictions for groundwater use.	Potentially applicable.
Containment	Vertical Barriers	Subsurface Slurry Wall	Barrier wall formed by excavating a trench using a bentonite or other type of material to support the sides.	Not effective unless keyed into a continuous lower confining unit. Site lithology is not amenable to effective containment.
		Grout Curtain	Fixed vertical subsurface barrier formed by injecting a liquid slurry or emulsion under pressure into a rock or soil mass.	May not be effective in containing contminants due to soil gradation and difficulty in creating the grout curtain.
		Sheet Piling	Vertical barriers formed by piles which are interlocked at their edge and driven into place.	Eliminated because technology does not ensure effective seal.
Pump & Treat	Physical Treatment	Filtration	Process of separating and removing expended solids from a liquid by passing the liquid through a porous medium.	Potentially applicable as pretreatment or post treatment for the removal of suspended solids.
		Reverse Osmosis	The application of sufficient pressure to overcome osmotic pressure and force the net flow of water through the membrane toward the dilute phase. Used to concentrate inorganic/organic contaminants.	Potentially applicable.
		Ion-Exchange	A process whereby ions are removed from the aqueous phase by being exchanged with relatively non-hazardous ions held by the ion exchange material.	Potentially applicable.

Potentially applicable technology

Eliminated from further consideration

FIGURE 6-2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR SANDOVAL ZINC SITE, ILLINOIS

Response Actions	Remedial Technologies	Process Options	Descriptions	Screening Comments
			Groundwater/Surface Water (continued)	
Pump & Treat (continued)	Chemical Treatment	Chemical Precipitation	Process in which a dissolved contaminant is transformed into an insoluable solid and then removed by flocculation and sedimentation. The transformation to solids takes place at specific pH ranges for different contaminants and requires pH adjustment of the solution.	Potentially applicable.
Disposal	Groundwater Discharge	Off-Site Discharge	Disposal of extracted or treated groundwater to POTW.	Water must be transported to the POTW located in Centralia. The POTW applies the generated sludge for land applications and is therefore not willing to accept metal-bearing groundwater without prior treatment.
		Recharge to Groundwater	Reinject treated groundwater using injection wells and pumps or infiltration trenches.	Eliminated because limited site area may pose problems with implementablity. Mounding of groundwater may occur.
		Discharge to Drainage Ditch	Discharge treated groundwater directly to drainage ditch water body.	Potentially applicable.
	Sludge Disposal	Off-Site Facility	Disposal of treatment wast streams and sludges at an off-site RCRA facility.	Potentially applicable.
Collection	Subsurface Drainage Systems	French Drain/ Interceptor	A system to collect or intercept and convey groundwater.	Potentially applicable.
	Diversion	Grading	Diversion systems are designed to collect stormwater and prevent it from running onto the site. Grading is performed to reduce surface water infiltration and control erosion.	Potentially applicable

Potentially applicable technology

Eliminated from further consideration

FIGURE 6-2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR SANDOVAL ZINC SITE, ILLINOIS

Response Actions	Remedial Technologies	Process Options	Descriptions	Screening Comments
			Soil	
Institutional Controls	Monitoring	Groundwater Monitoring	Perform water quality analyses to monitor contaminant migration and assess future environmental impact.	Potentially applicable.
	Access Restrictions	Deed Restrictions	Institute deed restrictions for impacted property.	Potentially applicable
		Fencing	Fence impacted property to isolate the site and minimize direct contact with contaminated soils.	This has already been inplemented by IEPA.
Containment	Capping	RCRA Cap	A cap that conforms to RCRA design criteria covering the soil to eliminate infiltration of precipitation and eliminate risk of exposure through inhalation and ingestion.	Potentially applicable
		Non-RCRA Cap	A cap of low permeability material to minimize infiltration of precipitation and reduce risk of exposure through inhalation and ingestion.	Potentially applicable.
		Vegetation	Consists of covering the surface soil on site with soil and seeding the soil for vegetation to minimize erosion and reduce risk of exposure through inhalation or ingestion.	Potentially applicable.

Potentially applicable technology

Eliminated from further consideration

sand1.wk1

FIGURE 6–2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR SANDOVAL ZINC SITE, ILLINOIS

Response Actions	Remedial Technologies	Process Options	Descriptions	Screening Comments
			Soil (continued)	
Treatment	Physical/Chemical Treatment	Chemical Extraction	Treatment of soil with acid solutions to remove metals.	Not feasible because the majority of impacted soil consists of slag which contains high levels of heavy metals. The slag is also not easily reduced in size to expose the metals for extraction.
		Electro Reclamation	An electric current is passed through electrodes imbedded in the soil. Metal contaminants migrate to negatively charged electrodes and are captured in the chemical solution circulating in the electrode.	The subsurface soils at the site consist of silty clays which do not have a high hydraulic conductivity. As a result, recover efficiencies are not expected to be high.
		Soil Washing	Removes contaminants from soils using a washing fluid with appropriate surfactants, acids or chelating agents.	Subsurface soils at the site consist primarily of slag. As a result the metals associated with the impacted soil have not been adsorbed but are inherent. Therefore, soil washijng would not be effective.,
	Solidification/ Stabilization	On–Site Stabilization/ Solidification	Excavated impacted soils are mixed with stabilizing agents and other additives above ground to produce a stabilized material. The process immobilizes contaminants within a solid matrix.	Impractical because the volume of resultant product will increase substantially over the original volume.
		In–Situ Stabilization/ Solidification	Stabilizing agents are put directly into the impacted soil through a rotating shaft. At the end of the treatment, a treated block of soil remains. The process immobilizes contaminants within a solid matrix.	Potentially applicable.
	Metals Recovery	Thermal Processes	Soils excavated and thermally treated to recover metal.	Potentially applicable.
		Heap Leaching	Soils excavated and leached with suitable reagents in heaps on impervious pads.	Potentially applicable.

Potentially applicable technology

Eliminated from further consideration

FIGURE 6-2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR SANDOVAL ZINC SITE, ILLINOIS

Response Actions	Remedial Technologies	Process Options	Descriptions	Screening Comments
			Waste Product / Ash and Debris	
Disposal	Excavation & Land Disposal	Off-Site Secure Landfill	Excavated impacted soilds disposed of in an off-site RCRA landfill.	Potentially applicable.
		On-Site Secure Landfill	Excavated impacted soilds disposed of in an off-site RCRA landfill.	Not applicable. Site is too small to construct a secure landfill.
Disposal	Excavation & Disposal	Off-Site Secure Landfill	Excavate the waste product / ash and debris stored on-site and dispose in a secure RCRA landfill.	Potentially applicable.
			Above Ground Storage Tank	
Closure	Decontamination and Disposal	Off-Site Disposal	Empty residual fuel oil from the tank and dispose off-site appropriately. Remove the tank and dispose off-site after decontamination.	Potentially applicable.
		Abandon in Place	Empty residual fuel oil from the tank and dispose off-site appropriately. Abandon the tank in place.	Potentially applicable.

Potentially applicable technology

Eliminated from further consideration

FIGURE 6-2
INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS
FOR SANDOVAL ZINC SITE, ILLINOIS

Response Actions	Remedial Technologies	Process Options	Descriptions	Screening Comments
			Farm Pond Sediments	
Treatment	Solidification/ Stabilization	On-Site Stabilization/ Solidification	Excavated impacted sediments are mixed with stabilizing agents and other additives above ground to produce a stabilized material. The process immobilizes contaminants within a solid matrix.	Potentially applicable.
		In-Situ Stabilization/ Solidification	Stabilizing agents are put directly into the impacted sediment using backhoes. At the end of the treatment, a treated block of sediments remains. The process immobilizes contaminants within a solid matrix.	Potentially applicable.
Disposal	Excavation & Disposal	Off-Site Secure Landfill	Excavate the impacted sediments and dispose in a secure RCRA landfill	Potentially applicable.

Potentially applicable technology

Eliminated from further consideration

FIGURE 6-3
EVALUATION OF PROCESS OPTIONS
Sandoval Zinc Site, Illinois

Response Actions	Remedial Technologies	Process Options	Effectiveness	Implementability	* Cost
No Action	None	Not Applicable	Does not achieve Remedial Action Objectives (RAO's).	Not applicable.	None
			GROUNDWATER		
Institutional Controls	Monitoring	Groundwater Monitoring	Does not achieve Remedial Action Objectives (RAO's) May be used in conjunction with other process options.	Readily implementable.	Low
	Groundwater Restrictions	Deed Restrictions	Does not achieve RAO's. May be used in conjunction with other process options.	May be acceptable to local public or government agencies with additional process options.	Nominal
Pump & Treat	Physical Treatment	Filtration	Effective for removal of suspended solids. Should be coupled with another technology for pre or post treatment process.	Readily implementable.	Low
		Reverse Osmosis	Effective for removal of metals. Process creates brine waste stream that may require treatment.	Readily implementable. Large volume of brine waste requiring treatment is generated.	High
		Ion-Exchange	Effective for removal of metals. Resins are selective and may remove multiple ions. Process creates regenerate solutions that require treatment.	Readily implementable. Concentrated spent regenerate is created which requires treatment.	High
	Chemical Treatment	Chemical Precipitation	Effective and reliable for metals removal. Process creates sludge that requires sludge disposal.	Readily implementable.	Low to Moderate

Retained as a representative process option

Eliminated from further consideration

* Groundwater
Low Cost = 0.20 – \$1.00/1000 gallon
Moderate Cost = \$1–\$5/1000 gallon
High Cost = \$5/1000 gallon

* Soil
Low cost = \$20–\$70/cubic yard
Moderate Cost = \$70–\$120/cubic yard
High Cost = >\$120/cubic yard

FIGURE 6-3 (Continued)
EVALUATION OF PROCESS OPTIONS
Sandoval Zinc Site, Illinois

Response Actions	Remedial Technologies	Process Options	Effectiveness	Implementability	* Cost
			GROUNDWATER (continued)		
Disposal	Groundwater Discharge	Discharge to Drainage Ditch	Effective in discharge of treated groundwater.	Implementable.	Low
	Sludge Disposal	Off-Site RCRA Facility	Effective in disposal of treatment wastestreams and sludges.	Implementable.	High
Collection	Subsurface Drainage Systems	French Drain/ Interceptor	Effective in intercepting contaminated groundwater for treatment.	Implementable.	Low
	Diversion	Grading	Effective in reducing surface water infiltration and controlling erosion.	Implementable.	Low

Retained as a representative process option

Eliminated from further consideration

* Groundwater
Low Cost = 0.20 – $1.00/1000 gallon
Moderate Cost = $1–$5/1000 gallon
High Cost = $5/1000 gallon

* Soil
Low cost = $20–$70/cubic yard
Moderate Cost = $70–$120/cubic yard
High Cost = >$120/cubic yard

FIGURE 6-3 (Continued)
EVALUATION OF PROCESS OPTIONS
Sandoval Zinc Site, Illinois

Response Actions	Remedial Technologies	Process Options	Effectiveness	Implementability	* Cost
			SOIL		
Institutional Controls	Monitoring	Groundwater Monitoring	Does not achieve RAO's. May be used in conjunction with other process options.	Readily implementable.	Low
	Access Restrictions	Deed Restrictions	Does not achieve RAO's. May be used in conjunction with other process options.	May be acceptable to local, public or government.	Nominal
Containment	Capping	RCRA Cap	Effective in eliminating risk of exposure to contaminants through inhalation, ingestion and direct contact.	Implementable.	Moderate
		Non-RCRA Cap	Effective in reducing risk of exposure to contaminants through inhalation, ingestion and direct contact. Maintaining integrity of cap is a concern.	Implementable.	Low
		Vegetation	Effective in preventing soil erosion. Can be used in conjunction with capping to eliminate exposure to contaminants through inhalation, ingestion and direct contact	Implementable.	Low

Retained as a representative process option

Eliminated from further consideration

* Groundwater
Low Cost = 0.20 – $1.00/1000 gallon
Moderate Cost = $1 – $5/1000 gallon
High Cost = $5/1000 gallon

* Soil
Low cost = $20–$70/cubic yard
Moderate Cost = $70–$120/cubic yard
High Cost = >$120/cubic yard

FIGURE 6-3 (Continued)
EVALUATION OF PROCESS OPTIONS
Sandoval Zinc Site, Illinois

SOIL (continued)

Response Actions	Remedial Technologies	Process Options	Effectiveness	Implementability	* Cost
Treatment	Physcial/Chemical Treatment	Chemical Extraction	Available performance data indicates that RAO's are not likely to be achieved.	Has not been demonstrated on a commercial scale.	High
		Electro Reclamation	Cadmium & lead concentrations cannot be reduced to established cleanup standards.	The technology is under development and is not commercially available.	High
		Soil Washing	Based on available performance data, RAO's are not likely to be achieved. Extensive treatability studies required to determine optimum process conditions.	Lack of process control due to variations in soil composition is a concern.	Low to Moderate
	Solidification/ Stabilization	In-Situ Stabilization/ Solidification	Effective for long-term immobilization of the site in organic contaminants.	Implementable	Low to Moderate
	Metals Recovery	Thermal Processes	Processes effective for one metal may not be effective for another metal to the same degree. RAOs are not likely to be achieved for all metals of concern.	Process efficiencies have to be tested to ensure performance. Large volumes of soil require excavation and transportation off-site.	High
		Heap Leaching	Reagent effective for one metal may not be effective for another. Effective only during summer periods. RAOs not likely to be achieved.	The area available on-site is too small to implement this alternative.	High

Retained as a representative process option

Eliminated from further consideration

* Groundwater
Low Cost = 0.20 - $1.00/1000 gallon
Moderate Cost = $1-$5/1000 gallon
High Cost = $5/1000 gallon

* Soil
Low cost = $20-$70/cubic yard
Moderate Cost = $70-$120/cubic yard
High Cost = >$120/cubic yard

FIGURE 6–3 (Continued)
EVALUATION OF PROCESS OPTIONS
Sandoval Zinc Site, Illinois

Response Actions	Remedial Technologies	Process Options	Effectiveness	Implementability	* Cost
			SOIL (continued)		
Disposal	Excavation & Land Disposal	Off–Site Secure Landfill	Effective, but requires long–term management.	There are no secure landfills close by. Off–site disposal may also be impractical because of large volume of soil to be removed in order to achieve the RAO's.	High
			Waste Ash / Product & Debris		
Disposal	Excavation	Off–Site Secure Landfill	Effective in eliminating risk of exposure through source removal.	Implementable, although the waste must be transported a considerable distance.	Moderate to High
			Above Ground Storage Tank		
Closure	Decontamination and Disposal	Off–Site Disposal	Effective in eliminating risk of exposure through source removal.	Implementable	Low
		Abandonment in Place	Effective in eliminating risk of exposure assuming residual oil is properly disposed.	Implementable	Low

Retained as a representative process option

Eliminated from further consideration

* Groundwater
Low Cost = 0.20 – $1.00/1000 gallon
Moderate Cost = $1–$5/1000 gallon
High Cost = $5/1000 gallon

* Soil
Low cost = $20–$70/cubic yard
Moderate Cost = $70–$120/cubic yard
High Cost = >$120/cubic yard

FIGURE 6–3 (Continued)
EVALUATION OF PROCESS OPTIONS
Sandoval Zinc Site, Illinois

FARM POND SEDIMENTS

Response Actions	Remedial Technologies	Process Options	Effectiveness	Implementability	* Cost
Treatment	Solidification/ Stabilization	In–Situ Stabilization/ Solidification	Effective for long–term immobilization of the site in organic comtaminants.	Implementable	Low to Moderate
		On–Site Stabilization/ Solidification	Effective for long–term immobilization of the site in organic comtaminants.	Implementable	Low to Moderate
Disposal	Excavation	Off–Site Secure Landfill	Effective in eliminating risk of exposure through source removal.	Implementable, although the waste must be transported a considerable distance.	Moderate to High

☐ Retained as a representative process option

☐ Eliminated from further consideration

* Groundwater
Low Cost = 0.20 – $1.00/1000 gallon
Moderate Cost = $1–$5/1000 gallon
High Cost = $5/1000 gallon

* Soil
Low cost = $20–$70/cubic yard
Moderate Cost = $70–$120/cubic yard
High Cost = >$120/cubic yard

TABLE 6-1
SANDOVAL ZINC GROUNDWATER OBJECTIVES

PARAMETER (mg/kg)	OBJECTIVE	BASIS	ADL
Arsenic	0.2	WQC[1]	0.01
Cadmium	0.05	WQC	0.002
Chromium	1.0	WQC	0.01
Copper	1.3	WQC	0.025
Lead	0.1	WQC	0.005
Mercury	0.01	WQC	0.0002
Nickel	2.0	WQC	0.04
Selenium	0.02	WQC	0.005
Zinc	10.0	WQC	0.02
Manganese	10.0	WQC	0.015
Barium	2.0	WQC	0.2
Cobalt	1.0	WQC	0.05
Benzene	0.025	MCL[2] & treatability	0.002
Ethylbenzene	1.0	MCL & treatability	0.002
Toluene	2.5	MCL & treatability	0.002
Xylene	10.0	MCL	0.005
Acetone	0.7	RfD[3]	0.01
2-Butanone	0.35	RfD	0.1
Naphthalene	0.039	RfD & treatability	0.01
Acenaphthalene	2.1	RfD & treatability	0.018
Anthracene	10.5	RfD & treatability	0.0066
Flouranthene	1.4	RfD & treatability	0.0021
Fluorene	1.4	RfD & treatability	0.0021
Pyrene	1.05	RfD & treatability	0.0027
Total Carcinogenic PNAs	0.001	PMCL[4] & treatability	
-benzo (a) anthracene			0.00013
-benzo (a) pyrene			0.00023
-benzo (b) fluoranthene			0.00018
-benzo (k) fluoranthene			0.00017
-Chrysene			0.0015
-dibenzo (a,h) anthracene			0.0003
-indeno (1,2,3-c,d) pyrene			0.00043
Total Non-Carcinogenic PNAs	1.05	RfD for Pyrene	
-acenaphthylene			0.01
-benzo (g,h,i) perylene			0.00076
-phenanthrene			0.0064

1 WQC is the water quality criteria, USEPA 1972. Insufficient data are currently available for antimony, beryllium, silver and dibenzofuran. If contamination is detected following cleanup, COT should be contacted.
2 MCL is the maximum contaminant level, USEPA.
3 RfD is a reference dose, calculated by OCS.
4 PMCL is the proposed MCL
(1) Soil objectives for all heavy metals shall be based on an analysis using TCLP with results in mg/1.

TABLE 6-2: ESTIMATED MINIMUM VOLUMES OF SOIL FOR REMEDIATION

METALS IN SOIL	ESTIMATED MINIMUM[2] VOLUME OF SOIL TO BE REMEDIATED CUBIC YARD	ESTIMATED SOIL[1] CONCENTRATION AFTER REMEDIATION mg/kg	IEPA CLEANUP OBJECTIVES	BACKGROUND[1] SOIL CONCENTRATION
Cadmium	>330,555	<1	0.05	0.04-1.5
Copper	> 94,444	<100	1.30	10-30
Lead	>141,667	<100	0.10	10-40
Zinc	>425,000	<100	10.00	20-50

1 Source: J.P. Gibb and K. Cartwright, "Retention of Zinc, Cadmium, Copper and Lead by Geologic Materials", Cooperative Groundwater Report 9, Illinois State Water Survey (ISWS) and Illinois State Geological Survey (ISGS), 1982.

2 Represents the minimum volume of soil requiring remediation to achieve the concentrations listed in column 3.

Table 6-3
Feasible General Response Actions
And Associated Remedial Technologies
Sandoval Zinc
Sandoval, Illinois

RESPONSE ACTION	REMEDIAL TECHNOLOGIES
No Action	- None
Institutional Controls	- Groundwater Monitoring - Access Restrictions
Containment	- Groundwater Containment Vertical Barriers - Capping
Pump & Treat	- Physical Treatment - Chemical Treatment
Soil Treatment	- Physical/Chemical Treatment - Solidification/Stabilization - Metal Recovery
Excavation & Removal	- Soil Removal
Disposal	- Groundwater Discharge - Sludge Disposal - Excavation and Land Disposal
Collection	- Extraction Wells - Subsurface Drainage Systems - Diversion
Waste Product/Ash & Debris Disposal	- Off-Site Disposal
Above Ground Storage Tank Closure	- Off-Site Disposal

Table 6-4
List Of Process Options Retained
Sandoval Zinc
Sandoval, Illinois

REMEDIAL TECHNOLOGY	PROCESS OPTION
No Action	None
GROUNDWATER/ SURFACE WATER	
Institutional Controls	- Monitoring - Deed Restrictions
Pump & Treat	- Filtration - Reverse Osmosis - Ion Exchange - Chemical Precipitation
Collection	- Extraction Wells - French Drain/Inteceptor - Grading for diversion of Surface Water
Disposal	- Discharge to Off-Site Drainage Ditch
SOIL	
Institutional Controls	- Groundwater Monitoring - Deed Restrictions
Containment	- Non-RCRA Cap - RCRA Cap - Vegetation
Treatment	- Stabilization
WASTE ASH/ PRODUCT & DEBRIS	
Disposal	- Off-Site Disposal
ABOVE GROUND STORAGE TANK	
Disposal	- Off-Site Disposal
FARM POND SEDIMENTS	
Institutional Controls	- Groundwater Monitoring - Deed Restrictions
Treatment	- Stabilization

9.0 REFERENCES

1. J.P. Gibbs & K. Cartwright; Retention of Zinc, Cadmium, Copper and Lead by Geologic Materials, Cooperative Groundwater Report 9, Illinois State Water Survey, and Illinois State Geological Survey, 1982.

2. Illinois Water Pollution Act, Section 304.124, Subtitle C.

3. Ebasco Services Incorporated; Information Summary and Data Assessment Report, Sandoval Zinc Site, Sandoval, IL, April 14, 1989.

4. Hanson Engineers; Final Report of Survey Activities, Sandoval, IL, July 1989.

5. H.B. Willman, E. Atherton, T.C. Buschbach, C. Collinson, J.C. Frye, M.E. Hopkins, J.A. Lineback, & J.A. Simon; Handbook of Illinois Stratigraphy, Illinois State Geological Survey Bulletin 95, 1975.

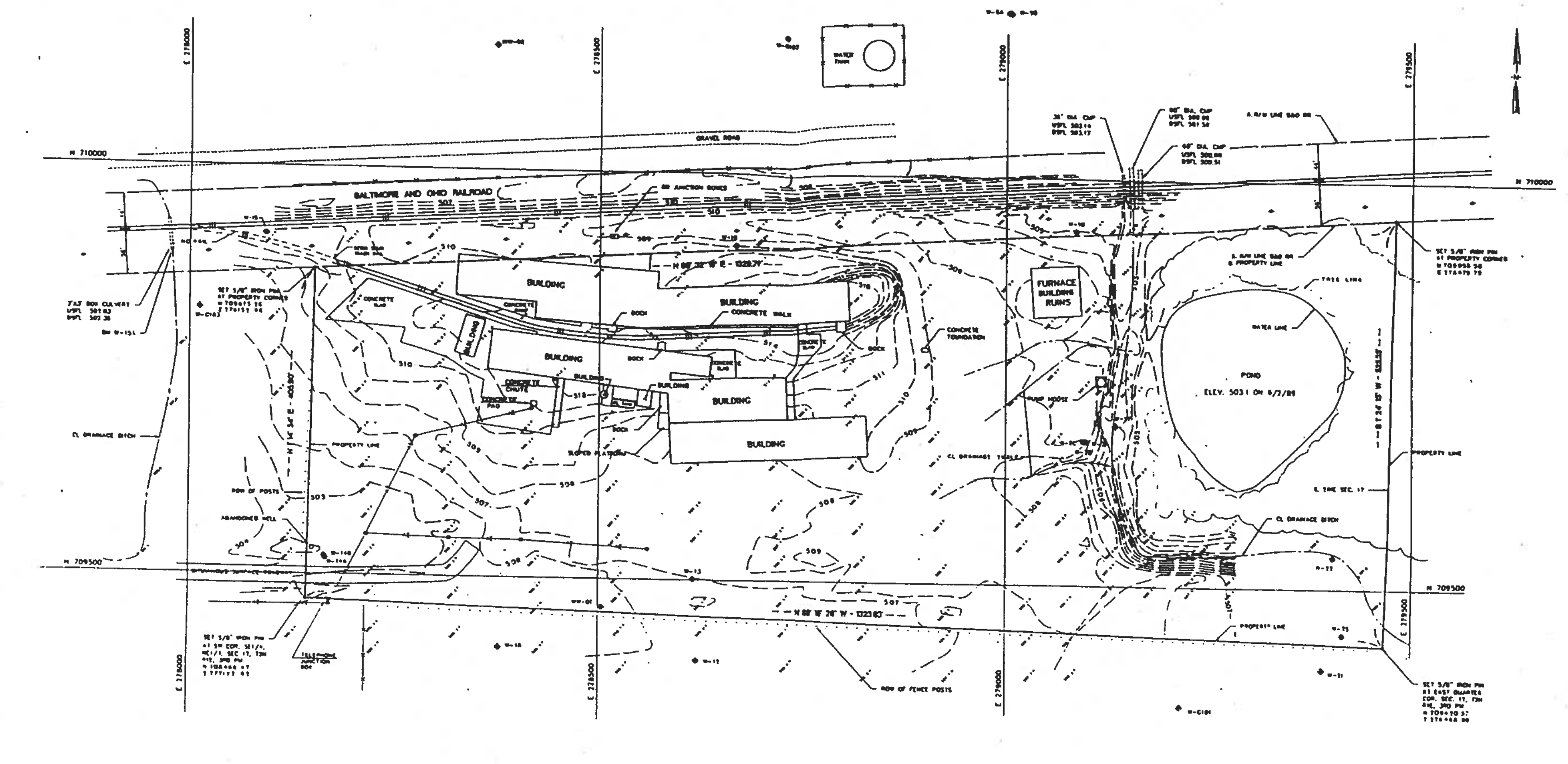
6. H.B. Willman & J.C. Frye; Pleistocene Stratigraphy of Illinois; Illinois State Geologic Survey Bulletin 94, 1970.

7. M.J. Hvorslev; Time Lag & Soil Permeability in Groundwater Observations, U.S. Army Corps of Engineers Waterways Exp. Sta. Bulletin 36, Vicksburg, Mississippi, 1951.

8. R.A. Freeze & J.A. Cherry; Groundwater, Prentice-Hall, Inc., New Jersey, 1979.

9. U.S. Environmental Protection Agency; Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, EPA/540/G-89/004, October 1988.

10. R.S. Means Company Inc., Means Heavy Construction Cost Data, 5th Annual Edition, 1991.

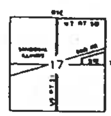


LEGEND

- POWER POLE
- COMMUNICATION POLE
- TELEPHONE JUNCTION BOX
- ELECTRIC LINE
- RAILROAD
- FENCE LINE
- MONITOR WELL

CONTOUR INTERVAL = 1'

SCALE 50 0 50 100



LOCATION MAP

BENCHMARK: USC&GS BM W-154, BRONZE DISK SET IN TOP OF THE EAST END OF THE SOUTH HEADWALL OF CONCRETE CULVERT UNDER THE TRACK AT THE NORTHWEST CORNER OF SITE EL. 507.26

BASIS OF BEARING: ILLINOIS STATE PLANE COORDINATE SYSTEM, EAST ZONE GRID FACTOR = 1.00000

MONITOR WELL DATA

WELL NO.	N. COORD	E. COORD	TOP CASE. ELEV.	GROUND ELEV.
W-2A	709678.58	279099.78	508.36	507.7
W-2B	709678.63	279097.85	508.51	507.9
W-2C	709678.88	279095.59	508.55	508.1
W-4A	709179.81	278160.72	509.81	507.3
W-4B	709179.12	278158.58	508.45	507.3
W-9A	710201.35	279002.32	508.55	505.0
W-9B	710200.67	279005.20	506.20	504.9
W-10	709938.21	279085.79	503.12	504.8
W-12	709500.78	278815.70	509.38	507.5
W-14A	709519.78	278188.73	507.83	504.8
W-14B	709572.45	278185.80	507.85	504.9
W-16	709414.28	278378.10	508.88	508.3
W-17	709401.70	278819.85	509.38	508.7
W-18	709812.31	278888.41	511.84	510.4
W-22	709443.98	279418.84	505.98	502.8
W-23	709538.78	279403.59	504.87	502.7
W-27	709894.83	279132.79	504.83	504.3
W-5A	709154.39	278871.10	510.38	507.7
W-5B	709154.27	278818.70	508.73	507.9
W-G101	709752.38	278214.82	512.87	509.5
W-G102	710170.98	278728.10	509.23	506.2
W-G103	709824.98	278011.90	508.15	505.3
MW-01	709403.85	278503.07	509.82	505.8
MW-02	710191.72	278973.81	509.58	507.0

WELLS W-15 AND W-21 WERE EXTENSIVELY DAMAGED. THE LOCATIONS SHOWN OF THESE TWO WELLS ARE APPROXIMATE. THE COORDINATES AND ELEVATIONS WERE NOT OBTAINED ON THIS SURVEY.

LEGAL DESCRIPTION

ALL THAT PART OF THE EAST ONE-HALF OF THE NORTHEAST ONE QUARTER OF SECTION 17, TOWNSHIP TWO NORTH, RANGE 1 EAST OF THE THIRD PRINCIPAL MERIDIAN, LYING SOUTH OF THE RIGHT OF WAY OF THE BALTIMORE AND OHIO SOUTHWESTERN RAILROAD.

TOTAL AREA = 618,667 S.F. OR 14.157 ACRES MORE OR LESS.

THIS IS TO CERTIFY THAT TO THE BEST OF MY KNOWLEDGE THIS IS A CORRECT PLAT OF A SURVEY MADE UNDER MY DIRECTION

DATE 7/12/89 [signature]
ILL. REGISTERED LAND SURVEYOR NO. 35-2166

REVISED 6/15/90 (ADD WELLS MW-01 & MW-02)

TOPOGRAPHIC & BOUNDARY SURVEY
SANDOVAL ZINC SITE
SANDOVAL, ILLINOIS

HANSON ENGINEERS INCORPORATED

DCB JPC

7/12/89

APPENDIX B

MONITORING WELL BORING LOGS
&
WELL CONSTRUCTION DIAGRAMS

BORING LOG

SHEET 1 OF ____

PROJECT NAME Sandoval Zinc

PROJECT NO. 8652.102

DATE 6/14/90

MW01

PROJECT LOCATION Sandoval, Illinois

RIG ____

LOGGED BY K. Webb DRILLED BY IEPA

WATER ENTERS ____

SURFACE ELEVATION 505.8 ELEVATION DATUM ____

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0 1 2	0-2.7	2.7/2.5		0-.55 Topsoil - med brown, sandy, moist. .55 - 1.5 Clay, high plasticity, damp, light brownish gray, mod. soft to 1.5', Abd. roots, mottled appearance.		0ppm OVA
3 4	2.7-5.5	2.7/2.5		1.5-2.5 Silty clay, mottled gray and brown, abd. black carbonaceous material, firm, damp,		0ppm OVA
5	5.5-10	4.2/4.5		2.5 - 3.6 Same as above, less black material, friable. 3.6-5.5 grades into sandy clay, high plasticity, med brownish gray, less mottling, damp 5.5 - 10.0 Sandy clay to clayey sand, same as above, scarce pebbles, becoming wet at base. 8.5' color becomes		0ppm OVA
10	10-15	5.0/5.0		reddish brown from oxidation, med. plasticity, becomes more gravelly with depth. Oxidation gives mottled appearance to sample 10.0 - 11.95 Clayey sand, reddish brown to gray (mottled appearance wet, low plasticity, abd. gravel. bottom .4' is light gray (no mottling).		0ppm OVA.
15		3.3/3		11.95-13.75 Clayey sand, reddish brown, 12.5' is band of gravel, wet, compact sand, abd. gravel throughout, no mottling, mod. firm 13.75 - 15.0 clayed sand, reddish brown to med gray, firm, abd. gravel, friable, bottom of sample appears to be cleaner sand 15.0 - 18.3 - clayey sand - sandy clay, med gray, hard, friable (same as 13.75 -15.0) Add. gravel, 16.5 - 16.8 is sand pocket, low plasticity poorly sorted.		0ppm

BORING LOG

SHEET) OF 1

PROJECT NAME Sandoval Zinc

PROJECT NO. 8652.102

DATE 6/15/90

RIG

WATER ENTERS

MW02B

PROJECT LOCATION MW-02B

LOGGED BY Philip Ross DRILLED BY IEPA

SURFACE ELEVATION 507.0 ELEVATION DATUM

DEPTH	SAMPLE TYPE	SAMPLE REC	SAMPLE RESIST	DESCRIPTION	U.S.C.	SPECIAL NOTES AND FIELD OBSERVATIONS
0	Continuous Sample	5/5		0-1.1 dark brown top soil, loamy 0.9-1.2 sandy layer, 1.2-5 gray silty clay, high plasticity, moist, orange mottling (oxidation) carbonaceous mat'l disseminated throughout. Abundant roots 0-2.5', decreasing mottling with depth No HCl reaction 0-5'		OVA=3.1 Top OVA = 0 bottom
5		4.5/5		~~5-10~~ 5-9.5 gray silty clay with trace sand and fine gravel. Poorly sorted, no apparent bedding Moist, high plasticity, orange mottling 9.5-10 - orange-brown color but otherwise as above. Carbonaceous mat'l throughout. No HCl reaction in this run.		OVA = 10 top OVA = 0
10'		4.8/5		10-12.8 orange-brown silty clay moderate plasticity, moist, trace sand and gravel. 12.8-13.5 silty sand with some clay, gray with some orange staining. 13.5-14.4 silty clay, gray, with considerable orange staining, high plasticity, moist 14.4-15 orange sand, some silt and clay. very wet. Graded contact above.		OVA = 0.4 Free water OVA=0.3
15		2.4/3		15-18 - brown fine gravel and coarse sand, non-cohesive, very wet. Sub-rounded to rounded grains. Heterogeneous lithologies for the clasts. ~~carbonaceous~~ downward. HCl reaction in sand.		OVA=0.8 Free water 0.2 - OVA
18		2/2		18-20 gray silty clay with some fine gravel. High plasticity, moist Virtually no oxidation, sharp contact with overlying sand. Strong HCl reaction from 18-20. Poorly sorted.		OVA=0 OVA=0
20				TD. After completion driller said the bottom of the hole was probably more		

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BORING NO.	WELL NO. G101 -	GROUNDLEVEL ELEV 103.73 *	PAGE 1 OF 2
COUNTY MARION	SITE NO. 1210500002	DATE START 4/6/87 FINISH 4/6/87	ANNULUS FILL MATERIAL ABOVE PACKING BENTONITE PELLETS 10'-11'
SITE SANDOVAL / ZINC			
BORING LOCATION SOUTHEAST AREA OF SITE NEAR WELL 21			PACKING SILICA SAND 11-17'
DRILLING EQUIPMENT CME 75	SIZE 3¼ CON. SAMPLE	TYPE 6¼ WELL	
COMPLETION DEPTH 17'	BEDROCK DEPTH	TOP OF CASING 3.3	TIME START 1:50 PM FINISH 7:30 PM
			SCREEN 2" PVC, 5', .01 SLOT
WELL CASING	TYPE AND QUANTITY PVC, SCH 40, 5' SCREEN, 10', 5'		PERSONNEL L. KEVIN ROGERS D. KEN BOSIE H. DALE HALFORD
SCREEN INTERVAL ~~12-17~~ 11.7-16.7	TYPE AND QUANTITY 5' PVC .01 SLOT		

ELEV.	DESCRIPTION	DEPTH FEET	Sample No	Sampler Type	Sample Recovery Ft	Penetrometer (Strength)	N Value (Blows)	REMARKS
	0-1.4' LOESS V.F., LT. BR., Fe STAIN MODERN SOIL ZONE							CON - CONTINUOUS
	1.4'-3.0 CLAY, SILTY, LT. BR. GRAY - DARK BR. SL. SAND	1, 2						* TEMPORARY BENCHMARK LOC. - CABLE TO TOWER
	3.0-7.0' SILTY CLAY, BR., SANDY, FEW PEBBLES LEACHED, OX	3, 4		CON. (0-5)	4.8			
	7.0-8.5' SILTY CLAY GRAY-RED, BR-BL. TRACE SAND, LEACHED, OX	5, 6, 7, 8		CON. (5-10)	5.0			
	8.5-11.2' SILT, RED-DARK BR. SANDY FEW PEBBLES	9, ▽ 10						
	11.2-11.5 CLAY. GRAY, SANDY	11						
	11.5-12.5 SAND, PEBBLEY, FINE-MED GRAIN TAN-BR. SAT. GRAY	12						
	12.5-12.8 CLAY, GRAY, SANDY, CALC.			CON. (10-)	4.7			
	12.8-14.1 TILL, GRAY BR-BLACK SAND, PEBBLES	13, 14						

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BORING NO.	WELL NO. G101	GROUNDLEVEL ELEV. 103.73*	PAGE 2 OF 2
COUNTY MARION	SITE NO. 1210500002	DATE START 4/6/87 FINISH 4/6/87	ANNULUS FILL MATERIAL ABOVE PACKING BENTONITE PELLETS 10-11'
SITE SANDOVAL / ZINC			
BORING LOCATION SOUTHEAST AREA OF SITE NEAR WELL 21		TIME START 1:50 PM FINISH 7:30 PM	PACKING SILICA SAND 11'-17'
DRILLING EQUIPMENT CME 75	SIZE 3¾ CON. SAMPLE	TYPE 6¼ WELL	
COMPLETION DEPTH 17'	BEDROCK DEPTH	TOP OF CASING 3.3	SCREEN 2" PVC, 5', .01 SLOT
WELL CASING	TYPE AND QUANTITY PVC, SCH 40, 5' SCREEN, 10', 5'		PERSONNEL L. KEVIN ROGERS D. KEN BOSIE H. DALE HALFORD
SCREEN INTERVAL ~~12-17'~~ 11.7-16.7	TYPE AND QUANTITY 5' PVC, .01 SLOT		

ELEV.	DESCRIPTION	DEPTH FEET	Sample No.	Sampler Type	Sample Recovery Ft.	Penetrometer (StrengtH)	N Value (Blows)	REMARKS
	14.7-15.0 SANDY ZONE							CON - CONTINUOUS
	15.0-16.2 TILL, LT GRAY-BR. MED SAND FEW PEBBLES CALC.	15		CON	1.7			* TEMPORARY BENCHMARK 100.0 CABLE TV TOWER
	16.2-17.0 TILL, DARK GRAY, SANDY, PEBBLES V. STIFF, CALC.	16						
	17' E.O.B.	17						

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BORING NO.	WELL NO. G102	GROUNDLEVEL ELEV. 101.54*	PAGE 1 OF 2
COUNTY MARION	SITE NO. 1210500002	DATE: START 4/7/87, FINISH 4/8/87	ANNULUS FILL MATERIAL: ABOVE PACKING BENTONITE PELLETTS 10.35-11'
SITE SANDOVAL ZINC			
BORING LOCATION NORTH OF PLANT NEAR WATER TANK			PACKING SILICA SAND 11'-17'
DRILLING EQUIPMENT CME 75	SIZE 3 3/4 SAMPLER	TYPE 6 1/4 WELL	TIME: START 9:30 Am, FINISH 9:45 Am
COMPLETION DEPTH 17.0	BEDROCK DEPTH	TOP OF CASING 3.0	SCREEN 2" PVC, 5', .01 SLOT
WELL CASING	TYPE AND QUANTITY PVC SCH 40, 5' SCREEN, 10', 5'		PERSONNEL: L-KEVIN W. ROGERS, D-KEN BOSIE, H-DALE HALFORD
SCREEN INTERVAL 12-17'	TYPE AND QUANTITY 5' PVC .01 SLOT		

ELEV.	DESCRIPTION	DEPTH FEET	Sample No.	Sampler Type	Sample Recovery Ft.	Penetrometer (Strength)	N Value (Blows)	REMARKS
	0-.7 LOESS V.F. LT BROWN W/PEBBLES VARIOUS SIZE BROWN-GRAY SANDY CLAY							CON - CONTINUOUS
		1						* TEMPORARY BENCHMARK 100.0 CABLE TV TOWER
	.7-2.7 BR-GR-BLACK, LEACHED, SANDY, PEBBLES SILTY CLAY, COLORFUL LEACH ZONE	2						
		3		CON	4.47			
		4						
	2.7-6.2 SILT, DARK GRAY, FEW BR. PEBBLES LEACHED	5						
		6						
	6.2-7.9 Lt. GRAY SILTY CLAY	7						
		8		Con.	5.0			
		9						
		10						
	7.9-12.2 RED-BR. SANDY CLAY W/ LARGE IGNEOUS PEBBLES	11						
		12		Con	4.6			
	12.2-12.8 SAND, V.F. GRAIN, GRAY, WELL SORT UNIFORM. SIZE, SATURATED	13						
	12.8-13.6 CLAY, BR. DARK, V.FINE MATRIX, PEBBLES							

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BORING NO.	WELL NO. G102	GROUNDLEVEL ELEV. 101.54 *	PAGE 2 OF 2
COUNTY MARION	SITE NO. 1210500002	DATE START 4/7/87 FINISH 4/8/87	ANNULUS FILL MATERIAL ABOVE PACKING BENTONITE PELLETTS 10.35 - 11' 1BUCKET
SITE SANDOVAL/ZINC			
BORING LOCATION NORTH OF PLANT NEAR WATER TANK		TIME START 9:30 AM FINISH 9:45 AM	PACKING SILICA SAND 11-17'
DRILLING EQUIPMENT CME 75	SIZE 3 3/4 SAMPLER	TYPE 6 1/4 WELL	
COMPLETION DEPTH 17.0	BEDROCK DEPTH	TOP OF CASING 3.0	SCREEN 2" PVC, 5', .01 SLOT
WELL CASING PVC SCH 40	TYPE AND QUANTITY 5' SCREEN, 10', 5'		PERSONNEL L-KEVIN W. ROGERS D-KEN BOSIE H-DALE HALFORD
SCREEN INTERVAL 12-17	TYPE AND QUANTITY 5' PVC, .01 SLOT		

ELEV.	DESCRIPTION	DEPTH FEET	Sample No.	Sampler Type	Sample Recovery Ft.	Penetrometer (Strength)	N Value (Blows)	REMARKS
	13.6-15.9 SAND, COARSE, UNSORTED, BROWN VARIOUS SIZE, FINER SIZE AT BOTTOM, SORTED IN BOTTOM	15						CON - CONTINUOUS
	15.9 - EOB TILL, BR-GRAY SILTY, CALC SANDY	16		CON	2.0			*TEMPORARY BENCHMARK CABLE TV TOWER
	17' EOB	17						.8 SAND BACKFILL

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BORING NO.	
WELL NO.	G103
GROUNDLEVEL ELEV.	100.53 *
PAGE 1 OF 2	
COUNTY	MARION
SITE NO.	1210500002
SITE	SANDOVAL/ZINC
BORING LOCATION	WEST OF PLANT NEAR DITCH
DRILLING EQUIPMENT	CME 75
SIZE	6 1/4
TYPE	WELL INSTALLED
COMPLETION DEPTH	17.0
BEDROCK DEPTH	
TOP OF CASING	3.0
DATE START	4/6/87
DATE FINISH	4/6/87
TIME START	11:30 Am
TIME FINISH	6:30 Pm
ANNULUS FILL MATERIAL ABOVE PACKING	BENTONITE PELLETS 10-11
PACKING	SILICA SAND 11-17
SCREEN	2" PVC, 5' .01 SLOT
WELL CASING TYPE AND QUANTITY	PVC SCH 40, 5' SCREEN, 5', 10'
SCREEN INTERVAL	12-17
TYPE AND QUANTITY	PVC 5' .01 SLOT
PERSONNEL	L- KEVIN W. ROGERS; D- KEN BOSIE; H- DALE HALFORD

ELEV.	DESCRIPTION	DEPTH FEET	Sample No.	Sampler Type	Sample Recovery Ft	Penetrometer (Strength)	N Value (Blows)	REMARKS
		1						
		2						AUGER DOWN TO 10' WITH REVERSE FLITE 6 1/4
	0-10.0 SURFACE PEAT, DARK BLACK GRASS, TWIGS, WET, ORGANIC MUCK	3–4						
		5–6						* TEMPORARY BENCH MARK CABLE TV TOWER
		7–9						
	10.0-12.3 SILTY CLAY, TAN TO BROWN	10–11		SPLIT SPOON	3.0		2, 2, 8	SPOON LENGTH 3.8 .6 EXTENSION
	12.3-14.3 SAND, LT GR-BROWN, V.F. SAND GRAIN SATURATED	12–13					10, 6, 7	
							1.4	

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BORING NO.	WELL NO.	GROUNDLEVEL ELEV.	PAGE 2 OF 2
	GW3	100.53 *	

COUNTY	SITE NO.	DATE START	DATE FINISH	ANNULUS FILL MATERIAL
MARION	1215000002	4/4/87	4/4/87	ABOVE PACKING: BENTONITE PELLETS 10-11

SITE: SANDOVAL/ZINC

BORING LOCATION: WEST OF PLANT NEAR DITCH

DRILLING EQUIPMENT	SIZE	TYPE	TIME START	TIME FINISH
CME 75	6 1/4	WELL INSTALLED	11:30 AM	6:30 PM

PACKING: SILICA SAND 11-17

COMPLETION DEPTH	BEDROCK DEPTH	TOP OF CASING	SCREEN
17.0		3.0	2" PVC, 5', .01 SLOT

WELL CASING — TYPE AND QUANTITY: PVC SCH 40, 5' SCREEN, 5', 10'

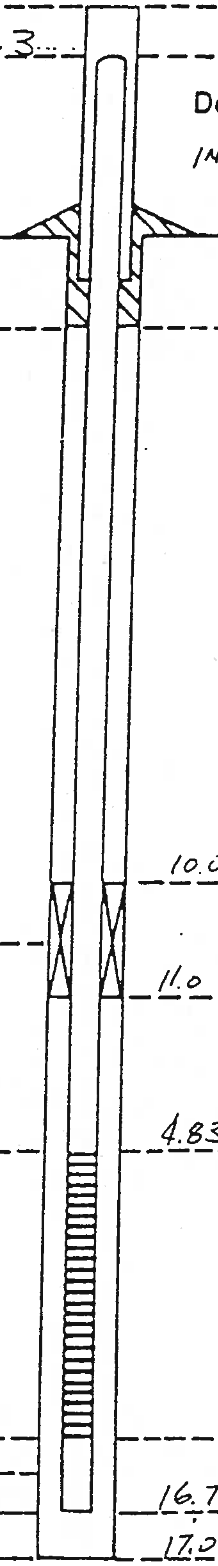
SCREEN INTERVAL: 12-17 — TYPE AND QUANTITY: PVC 5' .01 SLOT

PERSONNEL:
- L- KEVIN W. ROGERS
- D- KEN BOSIE
- H- DALE HALFORD

ELEV.	DESCRIPTION	DEPTH FEET	Sample No.	Sampler Type	Sample Recovery Ft.	Penetrometer (Strength)	N Value (Blows)	REMARKS
	14.3 - E.O.B TILL, GR-BR, PEBBLY, SANDY STILL, DRY, CALC.	15		SPLIT SPOON	3.0		24, 25, 33, 39	
		16						
	17.0 E.O.B.	17						* TEMPORARY BENCHMARK CABLE TV TOWER

MONITOR WELL CONSTRUCTION

Location: SANDOVAL/ZINC
Site No.: 1210500002
Well No.: G101
Prepared by: KEVIN W. ROGERS



Top of Protective Cover ( )

Top of Casing 3.3 (103.73)*

Depth (Elevation)
IN FEET

Ground Surface (100.43)*

Surface cap ( )

* TEMPORARY BENCH MARK 100.0
CONCRETE PAD FOR CABLE TV TOWER
NORTH EAST CORNER

Packed with
CEMENT GROUT
7.5 BAGS
TOP OF SEAL TO SURFACE
5% BENTONITE BY VOL

10.0 (90.43)*

Bentonite seal

11.0 (89.43)*

Packed with
BENTONITE PELLETS
<.5 BUCKET

11.7 4.83 (88.55)*

Packed with
SILICA SAND
3.0 BAGS

Screen
Total length 4.57

(83.72)*

Cap length .26

Bottom of casing 16.7 (83.46)*

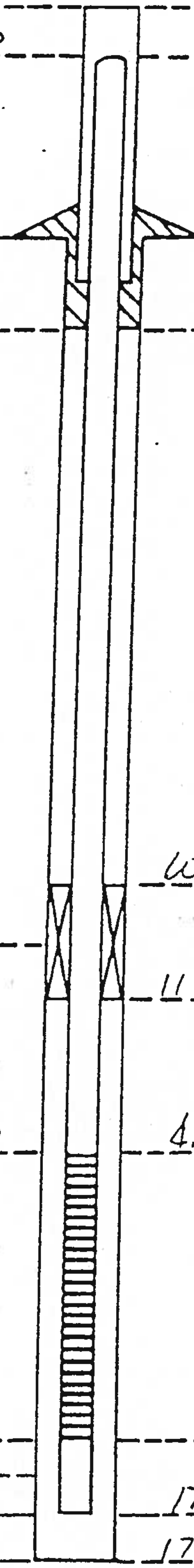
Bottom of boring 17.0 (83.43)*

Pipe: Type and quantity PVC SCH 40, 5' SCREEN, 10' SECTION, 5' SECTION

TOTAL WELL LENGTH 20.02. PROTECTIVE COVER 4" X 5'

MONITOR WELL CONSTRUCTION

Location: SANDOVAL/ZINC
Site No.: 1210500002
Well No.: G102
Prepared by: KEVIN W. ROGERS



Top of Protective Cover ( )
Top of Casing 3.0 (101.54)*

Depth (Elevation)
IN FEET

Ground Surface (98.54)*

Surface cap ( )

* TEMPORARY BENCH MARK 100.0
CONCRETE PAD FOR CABLE TV TOWER
NORTH EAST CORNER

Packed with
CEMENT GROUT
5.5 BAGS
TOP OF SEAL TO SURFACE
3% BENTONITE BY VOL.

10.35 (88.19)*

Bentonite seal 11.0 (87.54)*

Packed with
BENTONITE PELLETS
1 BUCKET

12.0 4.9 (86.44)*

Screen
Total length 4.~~84~~

Packed with
SILICA SAND
60 BAGS

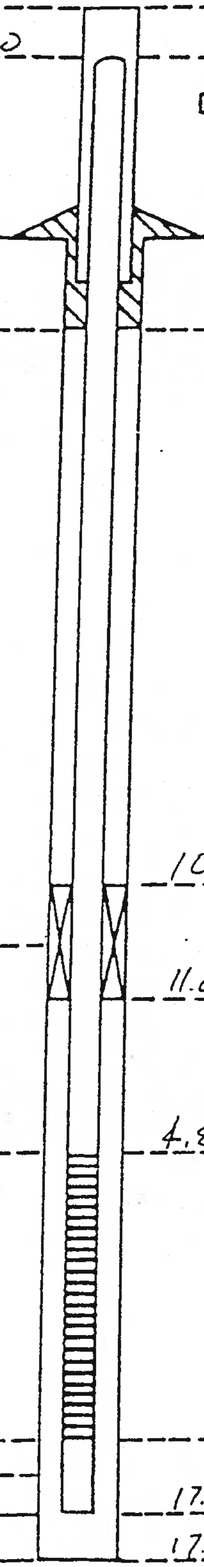
(81.80)*

Cap length .26
Bottom of casing 17.0 (81.54)*
Bottom of boring 17.0 (81.54)*

Pipe: Type and quantity PVC SCH 40, 5' SCREEN, 5' SECTION, 10' SECTION
TOTAL WELL LENGTH 20.1[illegible], PROTECTIVE COVER 4" X 5'

MONITOR WELL CONSTRUCTION

Location: SANDOVAL [illegible]
Site No.: 1210500002
Well No.: G103
Prepared by: KEVIN W. ROGERS



Depth (Elevation) IN FEET

Top of Protective Cover ( )

Top of Casing 3.0 (100.53*)

Ground Surface (97.53*)

Surface cap ( )

Packed with CEMENT GROUT
60 BAGS
TOP OF SEAL TO SURFACE
5% BENTONITE BY VOL.

* TEMPORARY BENCH MARK 100.0
CONCRETE PAD FOR CABLE TV TOWER
NORTH EAST CORNER

10.0 (87.53)

Bentonite seal

11.0 (86.53)

Packed with BENTONITE PELLETS
1 BUCKET

12.0 4.8 (85.33*)

Screen

Total length 4.55

Packed with SILICA SAND
4.75 BAGS

(80.78*)

Cap length .25

Bottom of casing 17.0 (80.53*)

Bottom of boring 17.0 (80.53*)

Pipe: Type and quantity PVC SCH 40, 5' SCREEN, 5' SECTION, 10' SECTION
TOTAL WELL LENGTH 20.03, PROTECTIVE COVER 4" X 5'

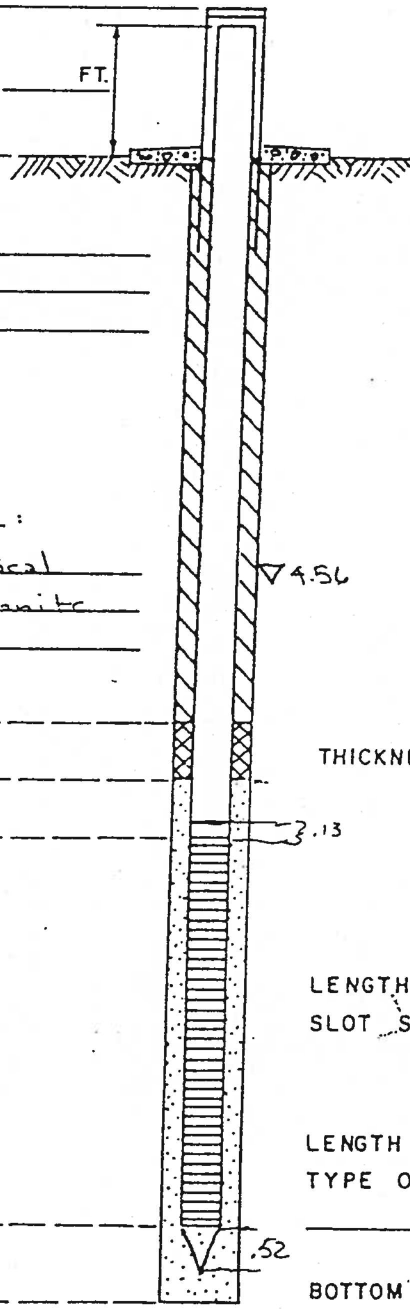
MONITORING WELL INSTALLATION REPORT

INSTALLED: 6/14/90
WELL NO.: MW-01
BORING NO.:
PROJECT NO.: 8652.102
PREPARED BY: K. Webb
CHECKED BY:

DEPTH BELOW GROUND SURFACE

_____ FT.

_____ FT. _____ FT.



TOP OF GROUND SURFACE EL. _____ FT.
RISER PIPE EL. _____ FT.
PROTECTIVE WELL COVER CASING:

GROUT MIX:

RISER PIPE SCHEDULE
ASTM DESIGNATION
I.D. 1.8 O.D. 2.0
COUPLINGS
PIPE IN 10.03 / 4.00 FT. LENGTHS

BENTONITE SEAL:
2' bentonite seal using ½" bentonite pellets

PIPE 1 10.03 FT.
PIPE 1 4.00 FT.
SCREEN 5 FT. + .65 including point and
TOTAL 19.68 FT.

6.76 FT.
8.76 FT.
10.76 FT.

THICKNESS OF UPPER SEAL _____ FT.

5.7
15.7

LENGTH OF SCREEN 5 FT.
SLOT SIZE 0.010 IN.

LENGTH OF FILTER PACK _____ FT.
TYPE OF FILTER PACK

15.76 FT.
18.0 FT.

BOTTOM OF BORING

REMARKS: .52 is length of point at base of screen
5.65 to top of

MONITORING WELL INSTALLATION REPORT

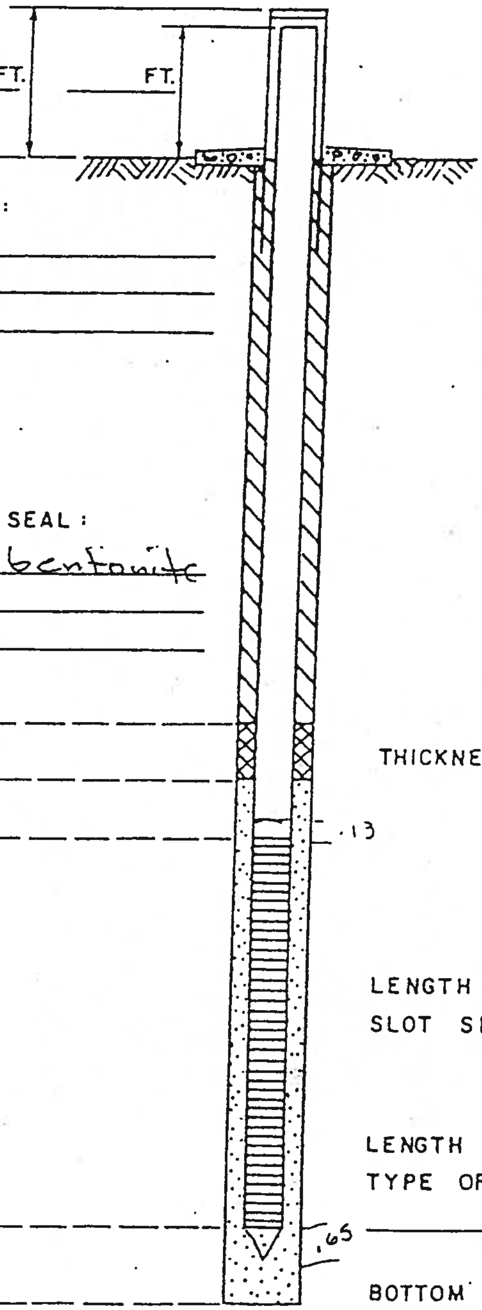
INSTALLED: 6/15/90
WELL NO.: MW02
BORING NO.:
PROJECT NO.: 8652.102
PREPARED BY: K. Webb
CHECKED BY:

79.00
18.72
56.28
5.65
10.6

DEPTH BELOW GROUND SURFACE

____ FT. ____ FT.

0 FT.



TOP OF GROUND SURFACE EL. ________ FT.
RISER PIPE EL. ________ FT.
PROTECTIVE WELL COVER CASING:

GROUT MIX:

RISER PIPE SCHEDULE ________
ASTM DESIGNATION ________
I.D. ________ O.D. ________
COUPLINGS ________
PIPE IN ________ FT. LENGTHS
PIPE ________ FT.
PIPE ________ FT.
SCREEN ________ FT.
TOTAL ________ FT.

19.00
5.65
13.3

BENTONITE SEAL:
2' 1/2" bentonite pellets.

9.30 FT.

11.30 FT.

THICKNESS OF UPPER SEAL ________ FT.

13.35 FT.

LENGTH OF SCREEN ________ FT.
SLOT SIZE ________ IN.

19.00
5.65
13.35
10.03
3.32

LENGTH OF FILTER PACK ________ FT.
TYPE OF FILTER PACK ________

19.0 FT.

20.5 FT.

BOTTOM OF BORING

REMARKS:

APPENDIX C

ANALYTICAL RESULTS OF SUPPLEMENTAL FIELD INVESTIGATION

KEY TO TABLES

CRDL	=	Contract Required Detection Limits
B	=	Compound Detected in Laboratory Blank
J	=	Concentration is Estimated
NA	=	Compound Was Not Analyzed
U	=	Compound Was Not Detected

TABLE C-1
INORGANIC CONCENTRATIONS (MG/KG) IN TANK SAMPLES

SAMPLING LOCATIONS

ANALYTE	CRDL	TS01S	TS01D
ALUMINUM	200.0	39 U	38 U
ANTIMONY	60	1.9 U	1.8 U
ARSENIC	10	0.96 U	0.95 U
BARIUM	200	9.9 U	9.0 U
BERYLLIUM	5	0.97 U	0.95 U
CADMIUM	5	0.97 U	0.95 U
CALCIUM	5000	190 U	190 U
CHROMIUM	10	1.9 U	1.9 U
COBALT	50	9.9 U	9.5 U
COPPER	25	4.8 U	4.8 U
IRON	100	41	34
LEAD	5	28	28
MAGNESIUM	5000	190 U	190 U
MANGANESE	15	2.9 U	2.8 U
MERCURY	0.2	0.063 U	0.059 U
NICKEL	40	17	17
POTASSIUM	5000	99 U	91 U
SELENIUM	5	0.96 U	0.95 U
SILVER	10	1.9 U	1.9 U
SODIUM	5000	99 U	91 U
THALLIUM	10	1.9 U	1.8 U
VANADIUM	50	49	46
ZINC	20	20	19
CYANIDE	10	NA	NA
BTU		18,500	17,800

TABLE C-2
VOLATILE ORGANIC CONCENTRATIONS (UG/L) IN TANK SAMPLES

SAMPLING LOCATIONS

ANALYSIS	CRDL	TS01S	TS01D
BENZENE	5.0	5000. U	5000. U
TOLUENE	1.0	4400. J	6700.
ETHYLBENZENE	5.0	20,000.	23,000.
XYLENES (TOTAL)	10.0	96,000.	92,000.

TABLE C-3
PCB CONCENTRATIONS (UG/KG) IN TANK SAMPLES

SAMPLING LOCATION

COMPOUND	CRDL	TS01S	TS01D
AROCLOR 1016	80.0	240,000 U	240,000 U
AROCLOR 1221	80.0	240,000 U	240,000 U
AROCLOR 1232	80.0	240,000 U	240,000 U
AROCLOR 1242	80.0	240,000 U	240,000 U
AROCLOR 1248	80.0	240,000 U	240,000 U
AROCLOR 1254	160.0	480,000 U	480,000 U
AROCLOR 1260	160.0	480,000 U	480,000 U

TABLE C-4
INORGANIC CONCENTRATIONS (MG/KG) IN SEDIMENT SAMPLES

SAMPLING LOCATIONS

ANALYTES	CRDL	SS01S	SS01D	SS02S	SS03S	SS04S	SS04R
ALUMINUM	200.0	18,000	12,000	9600	8560	13,600	200 U
ANTIMONY	60	3.4 U	3.1 U	4.0 U	3.1 U	16 U	10 U
ARSENIC	10	16	18	7.6	9.7	20	5.0 U
BARIUM	200	99	91	82	72	300	350
BERYLLIUM	5	1.6 U	1.4 U	1.8 U	1.5 U	2.2	5.0 U
CADMIUM	5	21	19	5.0	1.5 U	8.2	5.0 U
CALCIUM	5000	2500	2200	1700	1730	2960	12,600
CHROMIUM	10	18	3.8	22	3.1 U	13	10 U
COBALT	50	16 U	17	18 U	15 U	13 U	50 U
COPPER	25	820	850	440	330 J	1010 J	87
IRON	100	15,000	12,000	13,000	17,100 J	66,400 J	24,100 J
LEAD	5	2200	2000	490	190 J	2200 J	120
MAGNESIUM	5000	1700	1200	810	790	1720	1300
MANGANESE	15	260	1300	290	270	2770	170
MERCURY	0.2	0.17	0.14	0.099 U	0.095 U	0.83	0.20 U
NICKEL	40	440	470	180	190	490	198
POTASSIUM	5000	890	530	390	490	560	29,200
SELENIUM	5	1.6 U	1.4 U	1.8 U	1.5 U	2.8	5.0 U
SILVER	10	3.2 U	2.9 U	3.6 U	31	46	10 U
SODIUM	5000	250	230	190	150 U	130 U	94,800
THALLIUM	10	3.4 U	3.1 U	4.0 U	3.1 U	2.7 U	27
VANADIUM	50	28	20	18 U	15 U	99	50 U
ZINC	20	18,000	15,000	150,000	1410 J	1080 J	16,200

TABLE C-5
PCB CONCENTRATIONS (UG/KG) IN SEDIMENT SAMPLES

SAMPLING LOCATIONS

COMPOUND	CRDL	SS01S	SS01D	SS02S	SS03S	SS04S
AROCLOR 1016	80.0	1400 U	1300 U	1700 U	1600 U	120 U
AROCLOR 1221	80.0	1400 U	1300 U	1700 U	1600 U	120 U
AROCLOR 1232	80.0	1400 U	1300 U	1700 U	1600 U	120 U
AROCLOR 1242	80.0	1400 U	1300 U	1700 U	1600 U	120 U
AROCLOR 1248	80.0	1400 U	1300 U	1700 U	1600 U	120 U
AROCLOR 1254	160.0	2800 U	2500 U	3300 U	3200 U	230 U
AROCLOR 1260	160.0	2800 U	2500 U	3300 U	3200 U	230 U

TABLE C-6
INORGANIC CONCENTRATIONS (MG/KG) IN SURFACE SOIL SAMPLES

SAMPLING LOCATIONS

ANALYTE	CRDL	SS05S	SS05D	SS06S	SS07S	SS08S	SS09S	SS10S	SS10D	SS11S
ALUMINUM	200.0	11,300	11,000	7,520	6,000	6770	8990	7160	7,400	11,500
ANTIMONY	60	2.8 U	2.2 U	15 U	15	28	16	23	17	61
ARSENIC	10	13	6.7	7.9	21	57	55	12	21	38
BARIUM	200	200	130	84	150	190	200	290	270	130
BERYLLIUM	5	1.4	1.3 U	1.2 U	1.1 U	1.7	1.8	1.7	1.4	1.5 U
CADMIUM	5	1.4 U	1.3 U	1.2 U	1.1 U	3.7	21	67	35	1.5 U
CALCIUM	5000	10,900	3,500	96,800	14,300	1,830	3430	4570	2,440	1,640
CHROMIUM	10	2.8 U	5.1	2.4 U	24	9.5	16	98	18	60
COBALT	50	14 U	13 U	12 U	11 U	12 U	19	48	50	15 U
COPPER	25	190	73	100	350	4,290	4,250	5850	3,770	5,500
IRON	100	36,300	19,700	14,900	18,500	75,200	69,700	70,300	58,900	26,900
LEAD	5	510	130	250	4,000	41,000	16,000	11,000	6,200	21,000
MAGNESIUM	5000	3,310	1,290	5,460	300	590	550	1,180	480	830
MANGANESE	15	240	190	260	220	94	170	380	350	180
MERCURY	0.2	0.47	0.10 U	0.11	1.0	0.22	0.45	0.21	0.19	2.1
NICKEL	40	34	44	9.7 U	240	11	1,710	2,010	2,710	600
POTASSIUM	5000	1260	960	860	110 U	120 U	630	310	280	190
SELENIUM	5	1.7	1.3 U	1.2	1.1	2.8	2.8	1.6	1.7	3.6
SILVER	10	81	47	150	24	110	97	94	83	38
SODIUM	5000	220	130 U	310	110 U	200	470	380	280	190
THALLIUM	10	2.8 U	2.7 U	2.4 U	25	2.4 U	1.8 U	18	2.4 U	7.2
VANADIUM	50	14 U	13 U	12 U	11 U	43	110	97	77	15 U
ZINC	20	20,000	4200	2100	26,000	73,000	55,000	120,000	88,000	270,000

CRDL = CONTRACT REQUIRED DETECTION LIMITS

S = SAMPLE

D = DUPLICATE

R = RINSATE

J = ESTIMATED VALUE

TABLE C-6 (CONTINUED)
INORGANIC CONCENTRATIONS (MG/KG) IN SURFACE SOIL SAMPLES

SAMPLING LOCATIONS

ANALYTE	CRDL	SS12S	SS12R	SS13S	SS13D	SS14S	SS14R	SS15S	SS16S	SS16R	SS17S
ALUMINUM	200.0	11,800	200 U	12,900	10,300	8,600	200 U	11,100	10,400	200 U	8,810
ANTIMONY	60	19	60 U	13 U	2.4 U	2.6 U	60 U	2.2 U	150	60 U	25
ARSENIC	10	28	5.0 U	15	14	5.4	5.0 U	6.2	49	5.0 U	13
BARIUM	200	210	50 U	270	280	130	50 U	300	420	50 U	14 U
BERYLLIUM	5	1.3 U	5.0 U	1.1	1.6	1.0 U	5.0 U	1.2 U	1.8	5.0 U	1.4 U
CADMIUM	5	33	5 U	1.1 U	1,2 U	1.0 U	5 U	1.2 U	1.0 U	5 U	15
CALCIUM	5000	1,800	1,000 UJ	2030	990	980	1,000 UJ	630	5,210	1,000 UJ	1580
CHROMIUM	10	27	15	2.2	2.3 U	2.0 U	10	2.4 U	24	10 U	17
COBALT	50	13 U	50 U	11 U	12 U	10 U	50 U	12 U	10 U	50 U	14 U
COPPER	25	1350	53	490	520	100	35	6.0 U	2,880	25	3,000
IRON	100	35,300	66 J	36,500	42,100	15,900	50 UJ	22,300	57,600	64 J	37,400
LEAD	5	13,000	52	2,200	2,200	330	5 U	71	14,000	37	7,500
MAGNESIUM	5000	1,140	1,000 U	1,480	1,300	590	1000 U	800	490	1,000 U	750
MANGANESE	15	550	15 U	1,150	1,360	400	15 U	2,320	410	15 U	400
MERCURY	0.2	49	0.20 U	0.37	1.1	0.069 U	0.20 U	0.059 U	0.37	0.20 U	13
NICKEL	40	750	40 U	120	110	23	40 U	9.5 U	250	40 U	740
POTASSIUM	5000	260	500 U	730	530	470	500 U	640	480	500 U	140 U
SELENIUM	5	43	5.0 U	2.0	2.0	1.0 U	5.0 U	1.2 U	2.0	5.0 U	4.9
SILVER	10	54	10 U	64	67	23	10 U	43	91	10 U	42
SODIUM	5000	140	500 U	730	640	100 U	500 U	200	550	500 U	140 U
THALLIUM	10	2.6 U	10 U	2.2 U	2.3 U	2.0 U	10 U	2.4 U	2.1 U	10 U	22
VANADIUM	50	13 U	50 U	26	27	10 U	50 U	24	76	50 U	14 U
ZINC	20	240,000	3,200	25,000	21,000	1,900	440	2200	24,000	100	210,000

CRDL = CONTRACT REQUIRED

DETECTION LIMITS

TABLE C-6 (CONTINUED)
INORGANIC CONCENTRATIONS (MG/KG) IN SURFACE SOIL SAMPLES

SAMPLING LOCATIONS

ANALYTE	CRDL	SS18S	SS19S	SS20S	SS21S	SS22S	SS23S	SS24S	SS25S	SS26S	SS27S
ALUMINUM	200.0	6,130	6,530	7,770	10,700	7,310	6,540	5,710	8,910	9,630	6750
ANTIMONY	60	65	240	12 U	280	210	180	60	6.6	2.6 U	2.4 U
ARSENIC	10	1.1 U	28	12	31	18	23	35	9.5	8.7	5.3
BARIUM	200	11 U	160	75	290	120	68	74	89	150	120
BERYLLIUM	5	1.1 U	2.6	1.4	1.4	1.3	1.0	1.3 U	1.4 U	1.4 U	1.0 U
CADMIUM	5	48	27	1.0 U	27	10	3.7	1.3 U	1.4 U	1.4 U	1.0 U
CALCIUM	5000	4,180	23,500	1,670	29,200	2,090	4,500	750	960	480	1,270
CHROMIUM	10	13	73	4.4	8.3	14	16	2.6 U	2.7 U	2.7 U	2.0 U
COBALT	50	11 U	12 U	10 U	11 U	34	47	13 U	14 U	14 U	10 U
COPPER	25	1060	1,310	1,490	2,140	4,270	4,450	1,830	460	67	150
IRON	100	5380	126,000	32,100	56,600	44,600	54,100	43,200	16,300	21,000	18,400
LEAD	5	3200	6,300	1,300	7,600	4,300	14,000	28,000	830	170	15,000
MAGNESIUM	5000	2140	16,800	300	7,360	920	410	410	800	920	480
MANGANESE	15	340	3.5 U	4.2	320	120	290	13	390	1,790	910
MERCURY	0.2	1.4	5.7	0.45	0.66	0.53	0.46	7.7	0.11	0.098 U	0.081 U
NICKEL	40	490	450	780	1,410	2,500	3,460	600	240	25	66
POTASSIUM	5000	210	390	490	270	300	740	130 U	580	720	200
SELENIUM	5	1.1 U	9.6	1.4	1.5	1.3	2.5	5.5	1.4 U	1.4 U	1.0 U
SILVER	10	15	210	50	94	71	72	41	23	40	33
SODIUM	5000	160	180	260	130	200	620	130 U	140 U	140 U	100 U
THALLIUM	10	2.3 U	2.4 U	2.0 U	22	2.6 U	35	4.4	2.7 U	2.7 U	2.0 U
VANADIUM	50	11 U	100	10 U	78	66	95	13 U	14 U	17	10 U
ZINC	20	170,000	98,000	40,000	74,000	48,000	150,000	190,000	9,600	1,900	360,000

CRDL = CONTRACT REQUIRED

DETECTION LIMITS

TABLE C-7
PCB CONCENTRATIONS (UG/KG) IN SURFACE SOIL SAMPLES

SAMPLING LOCATION

PESTICIDES	CRDL	SS08S	SS10S	SS10D
AROCLOR 1016	80.0	1100 U	9600 U	9800 U
AROCLOR 1221	80.0	1100 U	9600 U	9800 U
AROCLOR 1232	80.0	1100 U	9600 U	9800 U
AROCLOR 1242	80.0	1100 U	9600 U	9800 U
AROCLOR 1248	80.0	1100 U	9600 U	9800 U
AROCLOR 1254	160.0	2100 U	19,000 U	20,000 U
AROCLOR 1260	160.0	2100 U	19,000 U	20,000 U

TABLE C-8
INORGANIC CONCENTRATIONS (MG/L) IN SURFACE WATER SAMPLES

SAMPLING LOCATIONS

ANALYTE	CRDL	SW01S	SW01D	SW02S	SW03S	SW04S	SW04R
ALUMINUM	200.0	780	1000	5,200	5,600	660	200 U
ANTIMONY	60	60 U	60 U	60 U	60 U	60 U	60 U
ARSENIC	10	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
BARIUM	200	52	98	78	84	55	50 U
BERYLLIUM	5	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
CADMIUM	5	360	370	5.0 U	5.0 U	5.0 U	5.0 U
CALCIUM	5000	100,000	110,000	17,000	5,300	18,000	1,000 U
CHROMIUM	10	10 U	10 U	10 U	10 U	10 U	10 U
COBALT	50	50 U	50 U	50 U	50 U	50 U	50 U
COPPER	25	90	80	85	90	79	25 U
IRON	100	1,400	1,400	3,200	3,300	3,200	50 U
LEAD	5	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
MAGNESIUM	5000	16,000	16,000	2,400	2,500	4,400	1,000 U
MANGANESE	15	1,500	1,600	84	120	930	15 U
MERCURY	0.2	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
NICKEL	40	100	100	40 U	40 U	40 U	40 U
POTASSIUM	5000	7,000	7,500	5,100	5,000	4,700	500 U
SELENIUM	5	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
SILVER	10	120	120	17	10 U	13	10 U
SODIUM	5000	27,000	33,000	6,200	5,700	14,000	500 U
THALLIUM	10	53	47	10 U	10 U	10 U	10 U
VANADIUM	50	50 U	50 U	50 U	50 U	50 U	50 U
ZINC	20	4,200 J	4,100 J	500 J	1,000 J	1,000 J	110 J

TABLE C-9
VOLATILE ORGANIC CONCENTRATIONS (UG/L) IN
SURFACE WATER SAMPLES
SAMPLING LOCATIONS

VOLATILES	CRDL	SW01S	SW01D	SW02S	SW03S	SW04S	SW04R (2)
BENZENE	5.0	5 U	5 U	5 U	5 U	5 U	5 U
TOLUENE	1.0	5 U	5 U	5 U	25 B	5 B	27 B
ETHYLBENZENE	5.0	5 U	5 U	5 U	5 U	5 U	5 U
XYLENES (TOTAL)	10.0	10 U	10 U	10 U	10 U	10 U	10 U

TABLE C-10
INORGANIC CONCENTRATIONS IN RESIDENTIAL WELL
WATER SAMPLES
SAMPLING LOCATIONS

ANALYTES	CRDL	RW01S	RW01D
ALUMINUM	200.0	200 U	200 U
ANTIMONY	60	60 U	60 U
ARSENIC	10	5.0 U	5.0 U
BARIUM	200	50 U	50 U
BERYLLIUM	5	5.0 U	5.0 U
CADMIUM	5	5 U	5 U
CALCIUM	5000	66,900 J	68,800 J
CHROMIUM	10	10 U	10 U
COBALT	50	50 U	50 U
COPPER	25	35	25 U
IRON	100	2,700 J	2,660 J
LEAD	5	5 U	5 U
MAGNESIUM	5000	8,370	8,400
MANGANESE	15	160	160
MERCURY	0.2	0.20 U	0.2 U
NICKEL	40	40 U	40 U
POTASSIUM	5000	1,240	1,230
SELENIUM	5	5.0 U	5.0 U
SILVER	10	66	61
SODIUM	5000	12,300	12,400
THALLIUM	10	10 U	110
VANADIUM	50	50 U	50 U
ZINC	20	88	96
CYANIDE	10	NA	NA
BTU		NA	NA

TABLE C-11
INORGANIC CONCENTRATIONS (UG/L) IN GROUNDWATER SAMPLES

SAMPLING LOCATIONS

ANALYTES	CRDL	MW101S	MW101D	MW101R	MW102S	MW103S	MW01S TOTAL	MW01S DISSOLVED	MW02S TOTAL	MW02S DISSOLVED
ALUMINUM	200.0	200 U	200 U	200 U	200 U	200 U	14,000 J	500	13,000 J	200 U
ANTIMONY	60	60 U	60 U	60 U	60 U	60 U	7.0 U	7.0 U	7.0 U	7.0 U
ARSENIC	10	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	17	5.0 U	16	5.0 U
BARIUM	200	50 U	50 U	50 U	50 U	50 U	160	50 U	250	110
BERYLLIUM	5	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
CADMIUM	5	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	45	32	6.0	7.0
CALCIUM	5000	24,000	24,000	1,000 U	240,000 J	290,000 J	1,100,000	1,100,000	130,000	110,000
CHROMIUM	10	10 U	10 U	10 U	10 U	10 U	150	75	69	45
COBALT	50	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
COPPER	25	25 U	25 U	25 U	25 U	25 U	64	38	47	25 U
IRON	100	50 U	50 U	50 U	50 U	50 U	34,000 J	50 U	34,000 J	80
LEAD	5	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	29	2.0 U	34	4.1
MAGNESIUM	5000	13,000	13,000	1,000 U	170,000	150,000	360,000 J	380,000 J	46,000 J	38,000 J
MANGANESE	15	15 U	15 U	15 U	15 U	380	1,500 J	710	1,400 J	270
MERCURY	0.2	0.20	0.33	0.20 U	0.20 U	0.2 U	0.20 U	0.20 U	0.20 U	0.20 U
NICKEL	40	40 U	40 U	40 U	40 U	40 U	41	40 U	40 U	40 U
POTASSIUM	5000	670	670	500 U	1,400	3,000	6,500	3,000	5,900	2,200
SELENIUM	5	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
SILVER	10	43	40	10 U	420	450	140	48	11	10 U
SODIUM	5000	240,000	241,000	500 U	280,000	95,000	420,000	430,000	230,000	260,000
THALLIUM	10	10 U	10 U	10 U	180	190	5.0 U	5.0 U	5.0 U	5.0 U
VANADIUM	50	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U	50 U
ZINC	20	20 U	20 U	20 U	20 U	20 U	280	110	200	34
CYANIDE	10	NA	NA	NA	NA	NA	NA	NA	NA	NA
BTU		NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE C-12
VOLATILE ORGANIC CONCENTRATIONS (UG/L) IN
GROUNDWATER SAMPLES
SAMPLING LOCATIONS

VOLATILES	CRDL	MW01S	MW01T	MW02S	MW101S	MW101D	MW101R
BENZENE	5.0	5 U	5 U	5 U	5 U	5 U	5 U
TOLUENE	1.0	4 J	5 U	5 U	5 U	5 U	5 U
ETHYLBENZENE	5.0	5 U	5 U	5 U	5 U	5 U	5 U
XYLENES (TOTAL)	10.0	10 U	10 U	10 U	10 U	10 U	10 U

TABLE C-13
PCB CONCENTRATIONS (UG/L) IN GROUNDWATER SAMPLES

SAMPLE LOCATIONS

PCBS	CRDL	MW01S	MW02S	MW101S	MW101D	MW101R	MW102S	MW103S
AROCLOR 1016	80.0	0.50 U	0.50 U	1.0 U	0.50 U	0.50 U	1.0 U	0.50 U
AROCLOR 1221	80.0	0.50 U	0.50 U	1.0 U	0.50 U	0.50 U	1.0 U	0.50 U
AROCLOR 1232	80.0	0.50 U	0.50 U	1.0 U	0.50 U	0.50 U	1.0 U	0.50 U
AROCLOR 1242	80.0	0.50 U	0.50 U	1.0 U	0.50 U	0.50 U	1.0 U	0.50 U
AROCLOR 1248	80.0	0.50 U	0.50 U	1.0 U	0.50 U	0.50 U	1.0 U	0.50 U
AROCLOR 1254	160.0	1.0 U	1.0 U	2.0 U	1.0 U	1.0 U	2.0 U	1.0 U
AROCLOR 1260	160.0	1.0 U	1.0 U	2.0 U	1.0 U	1.0 U	2.0 U	1.0 U

TABLE C-14
INORGANIC CONCENTRATIONS (MG/KG) IN WASTE PILE
AND ASH SAMPLES
SAMPLING LOCATIONS

ANALYSIS	CRDL	WPA01S	WPA01D	WPA02S	WPA03S	WPA04S	WPA05S	WPA06S
ALUMINUM	200.0	74,000	79,000	37,000	27,000	10,000	15,000	1800
ANTIMONY	60	46	42	8.1	9.6	20	6.6	6.8
ARSENIC	10	14	17	29	26	29	28	9.3
BARIUM	200	9.5 U	10 U	200	94	170	100	14
BERYLLIUM	5	3.1	3.2	1.4	1.1 U	1.5	2.1	0.96 U
CADMIUM	5	16	10	32	51	30	53	50
CALCIUM	5000	690	910	11,000	3200	2400	3000	44
CHROMIUM	10	330	300	330	110	40	55	1.9 U
COBALT	50	44	44	62	12	13	11	9.6 U
COPPER	25	210	160	71,000	1000	3800	590	210
IRON	100	87,000	94,000	22,000	24,000	2300	62,000	3200
LEAD	5	1100	1000	63,000	3200	8300	4300	10,000
MAGNESIUM	5000	210	270	3000	2300	590	1500	120
MANGANESE	15	56	58	1200	450	250	650	150
MERCURY	0.2	0.065 U	0.059 U	0.25	0.70	0.063 U	0.30	0.059 U
NICKEL	40	430	450	14,000	450	2000	430	49
POTASSIUM	5000	780	830	140	2480	440	1360	170
SELENIUM	5	0.97 U	1.0 U	1.0 U	2.1	2.5	1.1	0.96 U
SILVER	10	2.3	2.0	5.3	2.3 U	2.1 U	2.1 U	1.9 U
SODIUM	5000	2610	2630	290	3530	570	1090	240
THALLIUM	10	1.8 U	1.8 U	2.1 U	3.9	2.1 U	6.6	1.9 U
VANADIUM	50	9.7 U	10 U	13	11 U	36	14	9.6 U
ZINC	20	260,000	260,000	220,000	290,000	680,000	240,000	27,000
CYANIDE	10	NA	NA	NA	NA	NA	4A	NA
BTU		NA	NA	NA	NA	NA	NA	NA

TABLE C-15
EP TOXICITY CONCENTRATIONS (MG/KG) IN
WASTE PILE AND ASH SAMPLES
SAMPLING LOCATIONS

ANALYTE	CRDL	WPA01S	WPA01D	WPA02S	WPA03S	WPA04S	WPA05S	WPA06S
ARSENIC	10	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
BARIUM	200	260	290	4000	1000	160	760	1200
CADMIUM	5	250	270	200	880	340	1500	210
CHROMIUM	10	10	8:6	8.7	6.9	12	7.2	6.2
LEAD	5	12	43	4000	8400	22,000	46,000	7100
MERCURY	0.2	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
SELENIUM	5	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
SILVER	10	10 U	10 U	10 U	10 U	10 U	10 U	10 U

TABLE C-16
VOLATILE ORGANIC CONCENTRATIONS (UG/L) IN GROUNDWATER SAMPLE

SAMPLING LOCATIONS

VOLATILES	CRDL	MW01T	MW102S	MW103S
CHLOROMETHANE	10.0	10. U	10. U	10. U
BROMOMETHANE	10.0	10. U	10. U	10. U
VINYL CHLORIDE	10.0	10. U	10. U	10. U
CHLOROETHANE	10.0	10. U	10. U	10. U
METHYLENE CHLORIDE	10.0	9. B	21. B	12. B
ACETONE	10.0	10. U	10. U	10. U
CARBON DISULFIDE	5.0	5. U	5. U	5. U
1,1-DICHLOROETHENE	5.0	5. U	5. U	5. U
1,1-DICHLOROETHANE	5.0	5. U	5. U	5. U
1,2-DICHLOROETHENE	5.0	5.U	5. U	5. U
CHLOROFORM	5.0	5. U	14. B	6. B
1,2-DICHLOROETHANE	5.0	5. U	5. U	5. U
2-BUTANONE	10.0	10. U	10. U	10. U
1,1,1-TRICHLOROETHANE	5.0	5. U	5. U	5. U
CARBON TETRACHLORIDE	5.0	5. U	5. U	5. U
VINYL ACETATE	10.0	10. U	10. U	10. U
BROMODICHLOROMETHANE	5.0	5. U	5. U	5. U
1,2-DICHLOROPROPANE	5.0	5. U	5. U	5. U
CIS-1,3-DICHLOROPROPENE	5.0	5. U	5. U	5. U
TRICHLOROETHENE	5.0	5. U	5. U	5. U
DIBROMOCHLOROMETHANE	5.0	5. U	5. U	5. U
1,1,2-TRICHLOROETHANE	5.0	5. U	5. U	5. U
BENZENE	5.0	5. U	5. U	5. U
TRANS-1,3-DICHLOROPROPENE	5.0	5. U	5. U	5. U
BROMOFORM	5.0	5. U	5. U	5. U
4-METHYL-2-PENTANONE	5.0	10. U	10. U	10. U
2-HEXANONE	10.0	10. U	10. U	10. U
TETRACHLOROETHENE	5.0	5. U	5. U	5. U
1,1,2,2-TETRACHLOROETHANE	5.0	5. U	5. U	5. U
TOLUENE	1.0	5. U	5. U	2. J
CHLOROBENZENE	5.0	5. U	5. U	5. U
ETHYLBENZENE	5.0	5. U	5. U	5. U
STYRENE	5.0	5. U	5. U	5. U
TOTAL XYLENES	5.0	5. U	5. U	5. U

TENTATIVELY IDENTIFIED				
UNKNOWN			5.	

APPENDIX D

ESTIMATION OF VOLUME OF SOIL AND GROUNDWATER FOR REMEDIATION

A. Estimation of Volume of Soil to be Remediated

The subsurface dimensions for the calculation were determined from the attached contour maps reproduced from the ISWS/ISGS report (Ref. 1). The surface dimensions were taken from the surveyed map presented in Appendix A, and also from the contour maps and average values used for calculations.

For the surveyed map, length = 9.1 inches
From the scale of the map, ¾ inch = 100 ft.

$$\text{Length} = \frac{4}{3} \times 100 \times 9.1 = 1{,}213 \text{ ft.}$$

From contour map, length = 3 inches
Scale, ¾ inch = 300 ft.

$$\text{Length} = \frac{4}{3} \times 300 \times 3 = 1{,}200 \text{ ft.}$$

Assume Average Length = 1,200 ft. (leaving allowance for some distance at the two ends).

From surveyed map, width = $2.62 \times \frac{400}{3} = 350$ ft.

From contour map, width = 1.25 x 400 = 500 ft.
Average width = (350 + 500)/2 = 425 ft.

From Figure 14, lowest zinc concentration = 100 mg/kg
Average depth = (23 + 23 + 22 + 23 + 22 + 22 + 21 + 29 + 18)/9 = 22.5 ft.
Volume to be remediated = (1,200)(425)(22.5)(1/27) = 425,000 $yd.^3$

From Figure 16, lowest cadmium concentration = 1 mg/kg
Average depth = (17 + 18)/2 = (17.5)
Volume to be remediated = (1,200)(425)(17.5)(1/27) = 330,555 $yd.^3$

From Figure 17, lowest copper concentration = 100 mg/kg
Average depth = (7 + 3)/2 = 5 ft.
Volume to be remediated = (1,200)(425)(5)(1/27) = 94,444 $yd.^3$

From Figure 18, lowest lead concentration = 100 mg/kg
Average depth = (8 + 7)/2 = 7.5 ft.
Volume to be remediated = (1,200)(425)(7.5)(1/27) = 141,667 $yd.^3$

B. Estimation of Volume of Groundwater to be Remediated

Assume average depth = 30 ft.
Depth to water table = 5 ft.
Net depth = (30-5) = 25 ft.
Width = 425 ft., Length = 1,200 ft.
Assume porosity = 15%
Volume of groundwater below water table = (1,200)(425)(25)(0.15) $ft.^3$ (7.48 gal/ft^3)
= 14.3×10^6 gallons

Add 10% to account for volume of water above water table.
Total volume to be remediated =
(1.1)(14.3×10^6) = 15.7×10^6 gallon

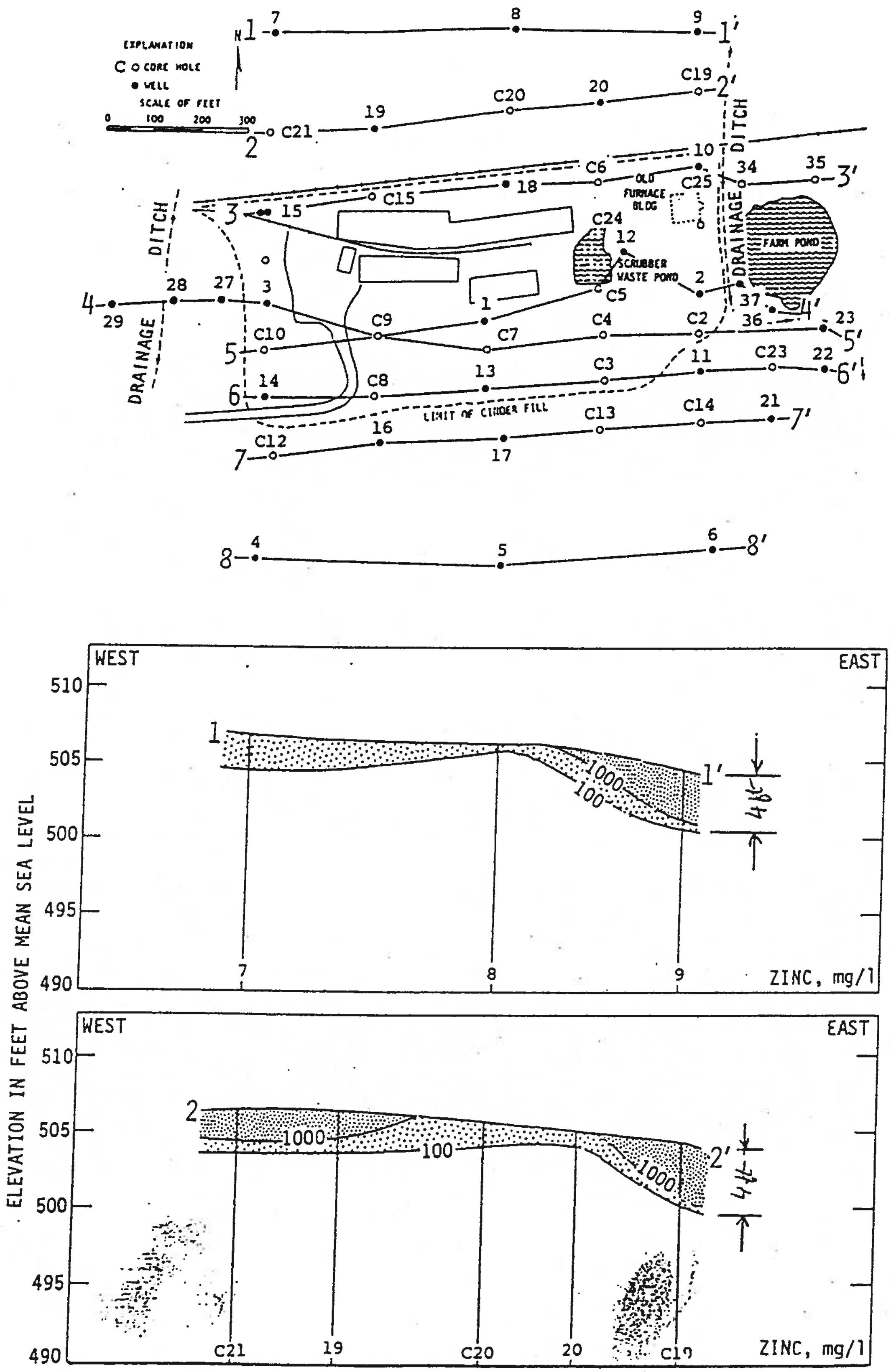


Figure 14. West-east profiles of zinc concentrations in soil — Site A

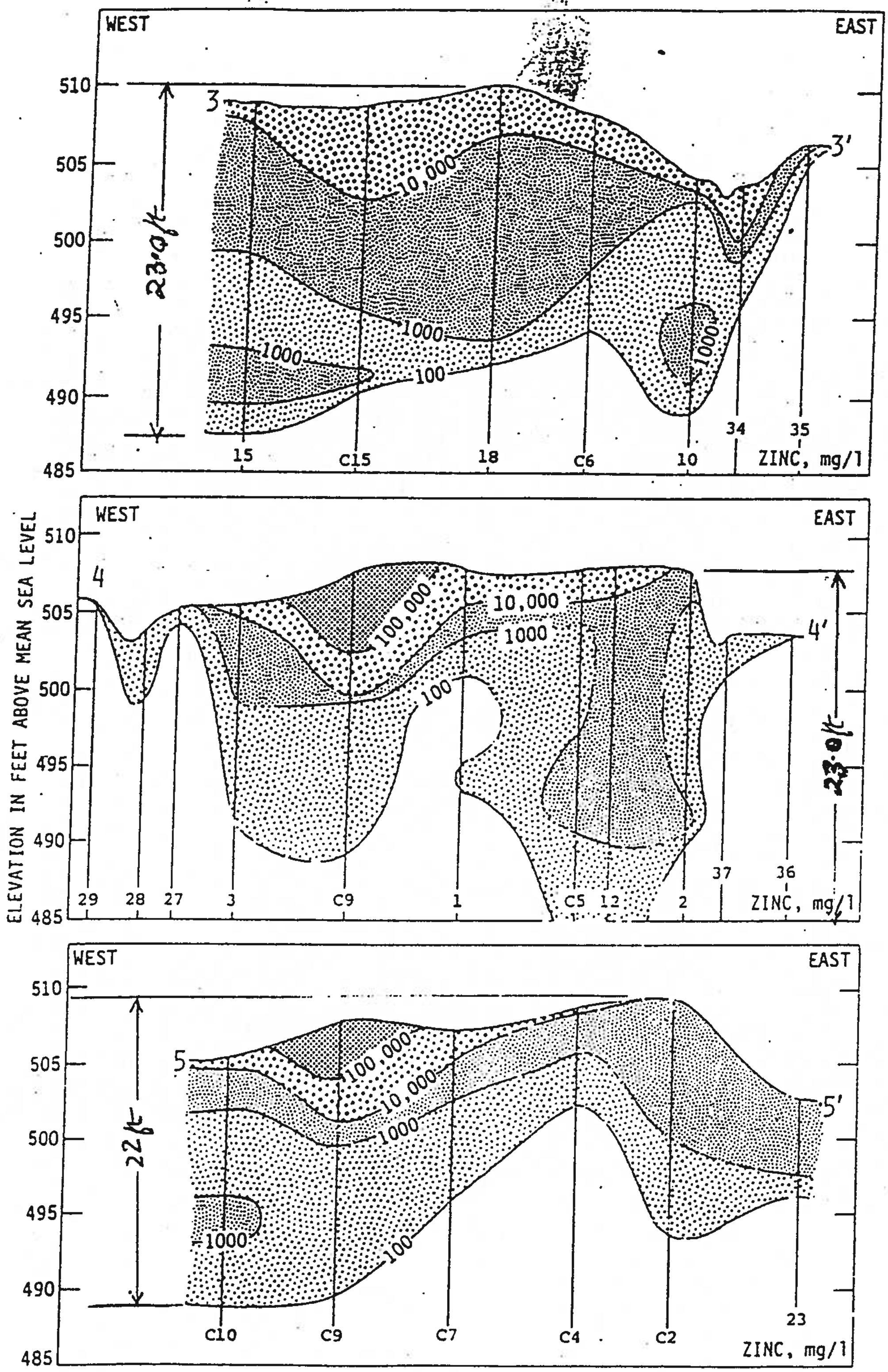


Figure 14. Continued

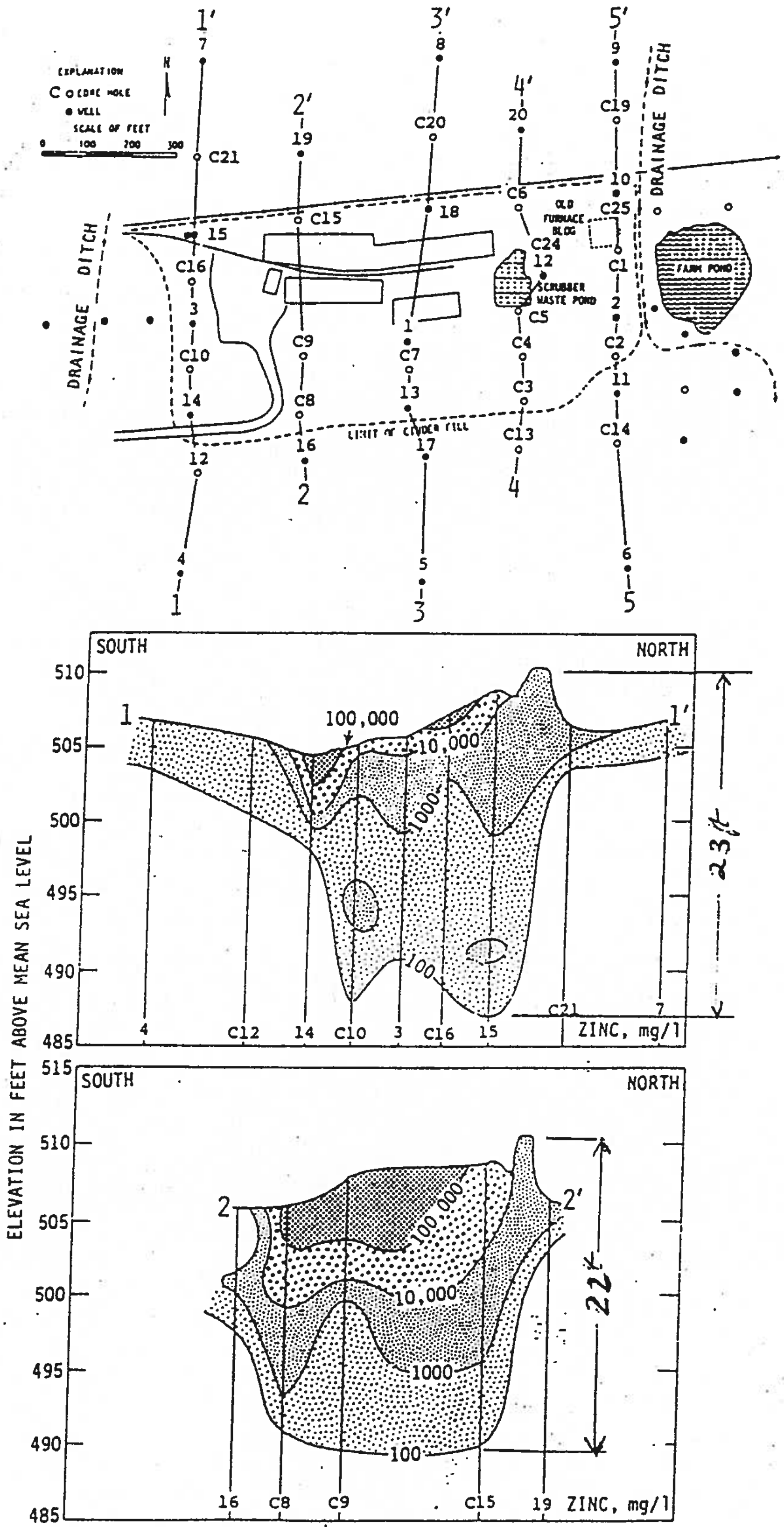


Figure 15. North-south profiles of zinc concentrations in soil — Site A

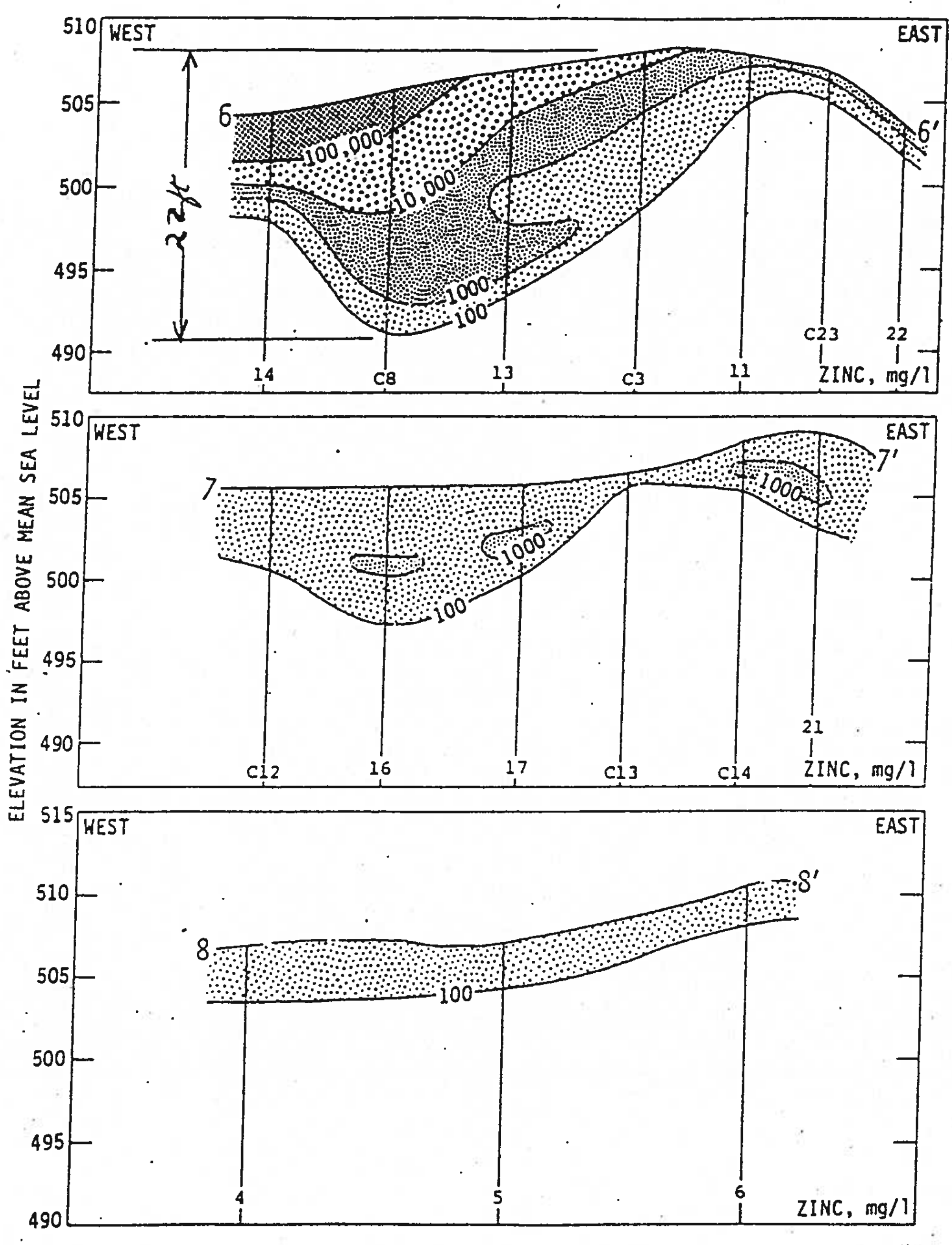


Figure 14. Concluded

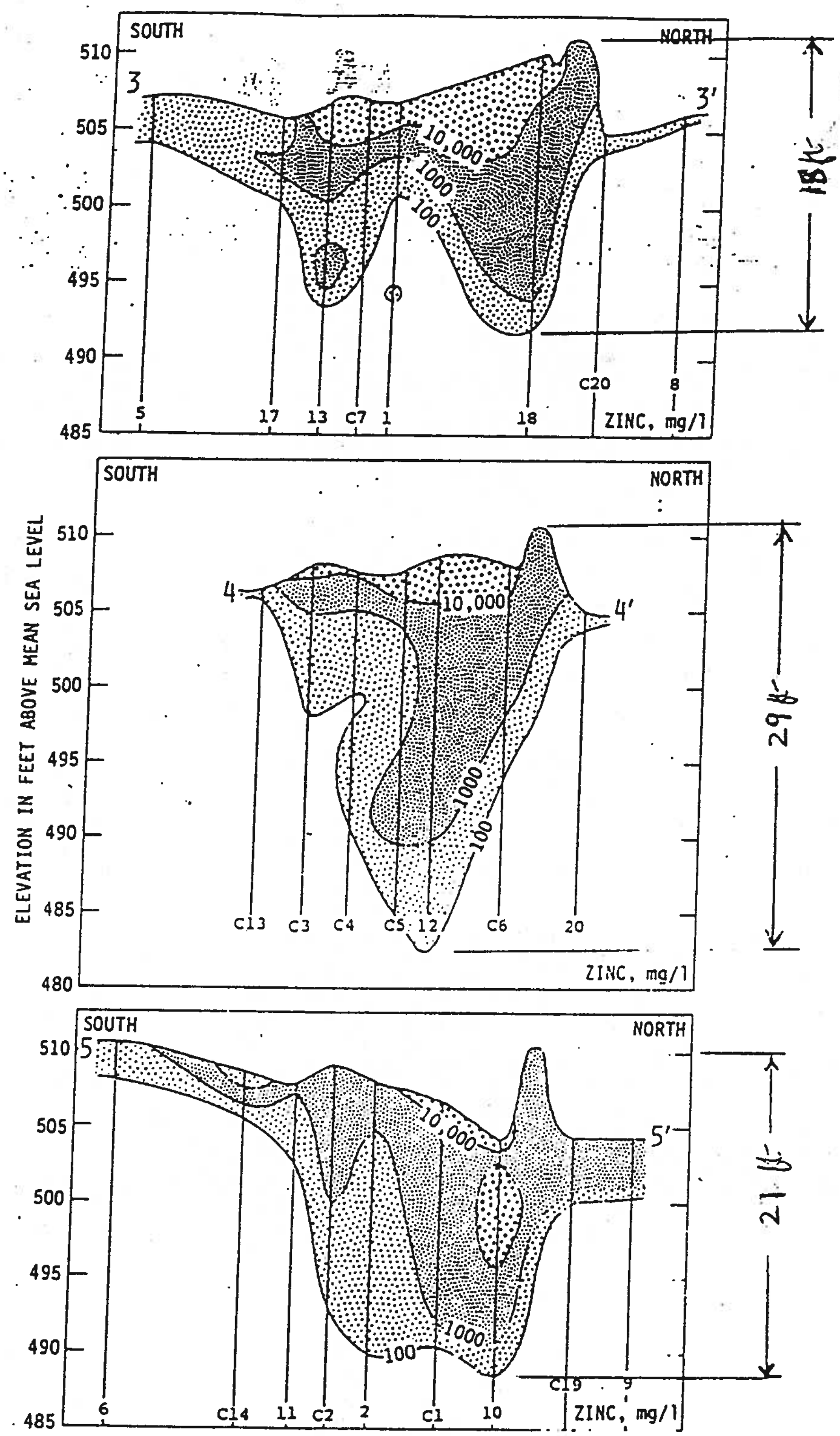


Figure 15. Concluded

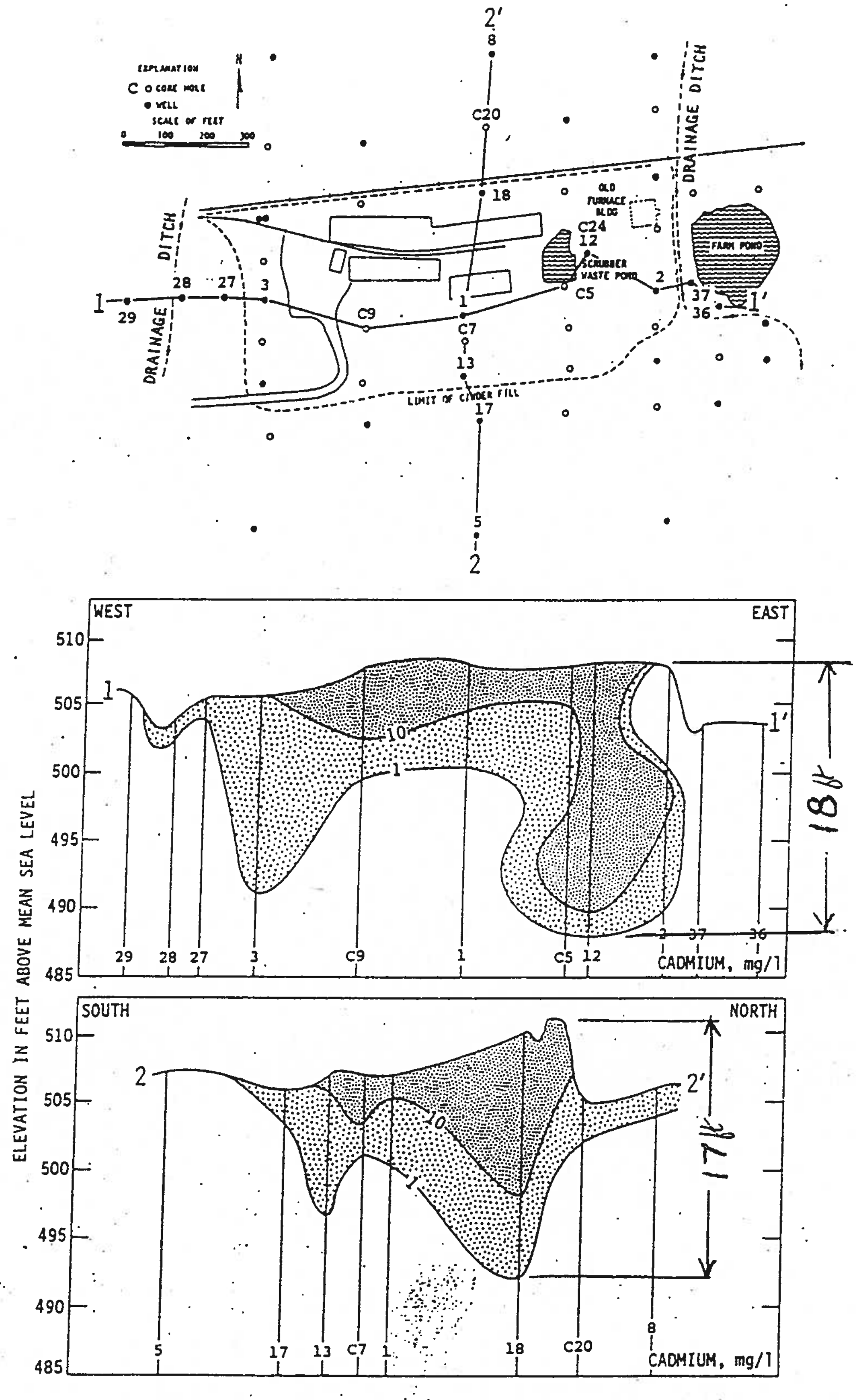


Figure 16. Profiles of cadmium concentrations in soil — Site A

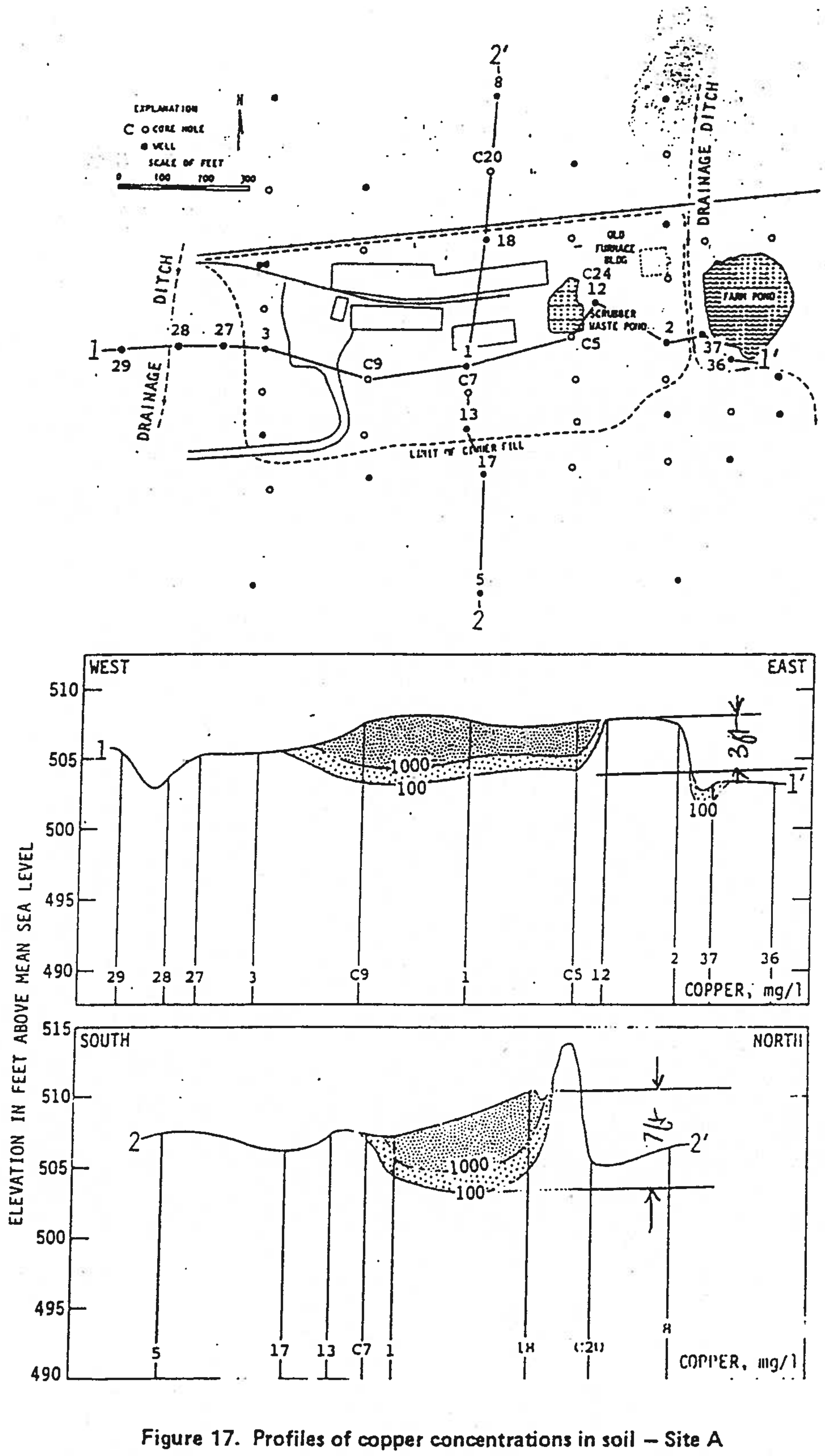


Figure 17. Profiles of copper concentrations in soil — Site A

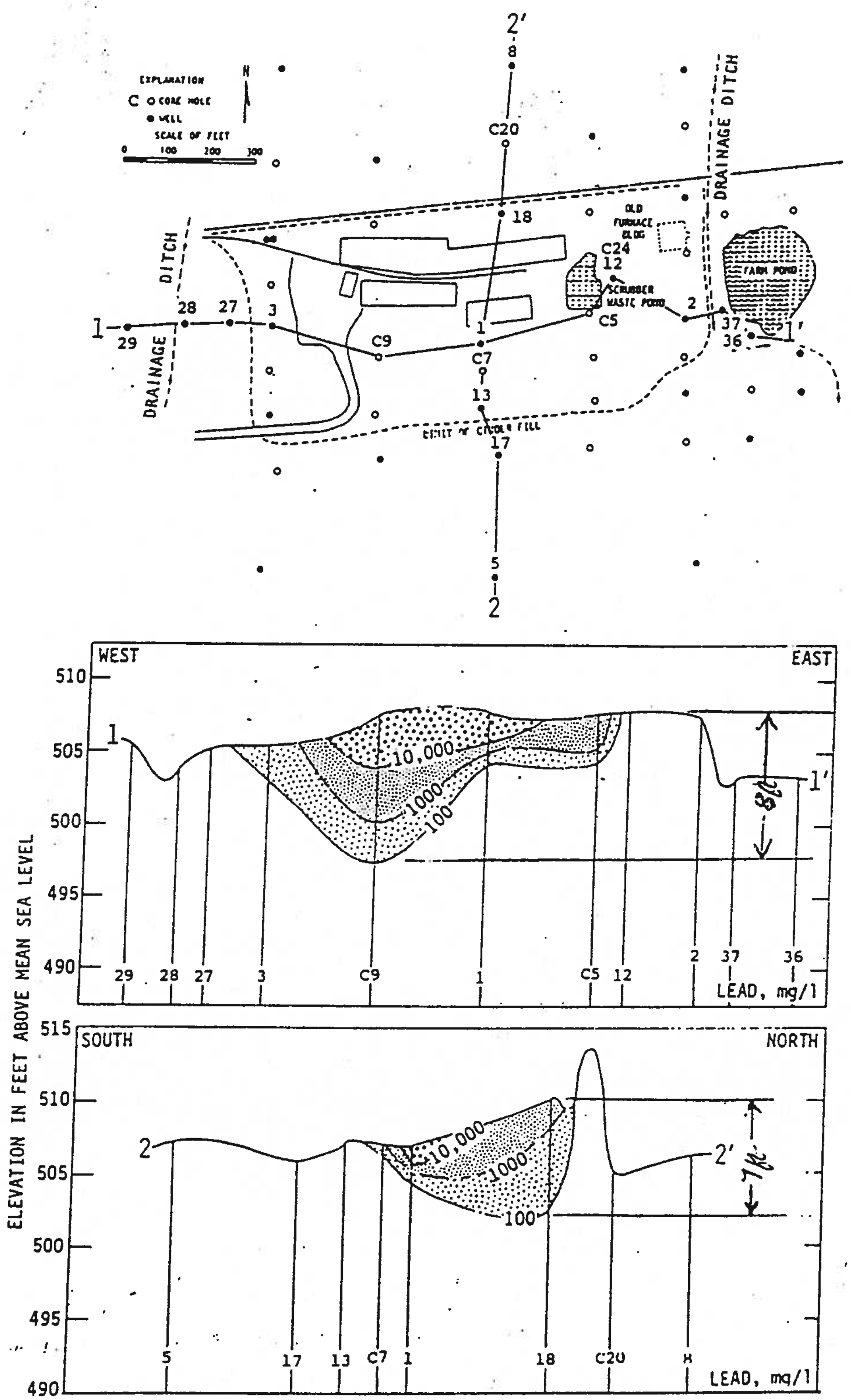


Figure 18. Profiles of lead concentrations in soil — Site A